CARBONIC-ACID SNOW

AS A THERAPEUTIC AGENT IN THE TREATMENT OF DISEASES OF THE SKIN

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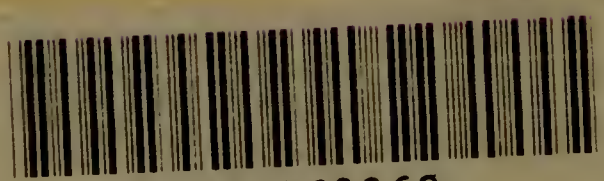

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CARBONIC-ACID SNOW

AS A THERAPEUTIC AGENT IN THE TREATMENT OF DISEASES OF THE SKIN

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BY

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PREFACE

Refrigeration by means of Carbon Dioxide Snow has now been accepted as a valuable method of treatment for certain diseases of the skin. It can be easily employed by the general practitioner, and the present volume aims at giving him the information which will enable him to carry it out successfully. A description of the methods of application is given, and the results obtained in the various diseases are indicated.

The majority of the cases herein reported were treated in the Skin Department of the Royal Infirmary, Edinburgh, under the charge of Dr. Norman Walker, and to him I am indebted for placing the clinical material so freely at my disposal.

The experimental and histological work was carried out at the Research Laboratory of the Royal College of Physicians, Edinburgh.

R. Cranston Low.

7 Castle Terrace, Edinburgh,
April 1911.

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SECTION I

INTRODUCTORY

The treatment of skin diseases by refrigeration is not a new one. It was first introduced in 1899 by Campbell White, who used liquid air for that purpose. Since then numerous workers have experimented with liquid air and other refrigerating substances, but owing to the difficulty in obtaining, transporting, and keeping liquid air, that substance has never come to be generally used. Ethyl chloride was used in 1900 by Dethlefsen, who reported good results from its use in lupus vulgaris, but ethyl chloride does not produce either rapid or very deep freezing, so that up till 1905 liquid air was the only substance which gave satisfactory results.

In 1905, however, Juliusberg, in Breslau, recommended the use of carbonic acid as a substitute for liquid air. He allowed the liquid carbonic acid to spray on the tissues and produced thereby an

instantaneous freezing of the part. His results were good, but it was difficult to apply and control the spray of CO_2. Later in the same year Pusey, in the United States, used carbonic acid in the solid form, and since then he has continued to do so with increasing success. Numerous other workers in America, in this country, and on the Continent, have now tried it, with the result that it bids fair to become a well-recognised method of treatment for certain skin affections where a sudden freezing of the tissues has been found to do good.

The results produced by freezing with liquid air and solid carbon dioxide are very similar. Liquid air has a temperature of 250° below zero C. (−418° F.). It is a bluish-white clear liquid, which, when poured out on the floor, rapidly evaporates. When applied to the tissues it causes instantaneous freezing. It explodes if kept in a tightly-corked vessel, and is usually transported in a "Dewar bulb," which consists of a smaller glass bulb inside a larger one, with a vacuum between. Liquid air can only be obtained in a few cities, and, as it requires expensive apparatus for its production, it is too dear for general use. It also rapidly evaporates, as the vessel, in which it is, must be plugged with cotton-wool only, so as to prevent explosion. A supply cannot be

kept for more than a few days. It is difficult to manipulate, and its action is difficult to measure and control.

In solid carbonic acid, however, we have a substance which, though not so cold as liquid air, yet is cold enough to produce all the effects of that substance. Solid carbonic acid has a temperature of −79° C. (−110° F.). The carbonic acid is obtained by the combustion of coke, and is a by-product in various industries. The carbonic-acid gas is condensed into the liquid form by pumping into cylinders under pressure. These cylinders can be easily obtained in all towns, and contain various quantities of the liquid carbonic acid, from 2 to 40 lbs. The pressure in the cylinders is from 850 to 1000 lbs. to the square inch, but varies with the temperature. On the average the pressure is 950 lbs. to the square inch, or a pressure of about 65 atmospheres. Liquid CO_2 has a co-efficient of expansion larger than that of any known body. When the CO_2 is allowed to escape in a liquid form it solidifies. This is due to the fact that when the liquid CO_2 is suddenly let out, and the pressure, under which it was, removed, there is a sudden expansion with an extremely rapid evaporation of CO_2 into the gaseous form, and in so doing there is a very great absorption of heat

from the remaining carbonic acid, which thus becomes solid. The solid CO_2 is white, and looks like ordinary snow. It soon evaporates into gas again unless it is compressed into a firm mass. When so compressed it will keep for an hour or two if wrapped in some badly-conducting substance, *e.g.* lint or cotton-wool. A mass of this snow can be held for a short time on the palm of the hand without producing any effect, because there is a constant evaporation of the gas, which forms a layer between the mass of CO_2 snow and the skin; but if the snow be pressed down on the skin so as to drive out this layer of gas, the skin is instantaneously frozen solid.

SECTION II

TECHNIQUE OF COLLECTING AND APPLYING CO_2 SNOW

The method of spraying the liquid carbonic acid directly on to the skin, as Juliusberg did, has been found unsatisfactory, owing to the difficulty of controlling the result. A great many methods, all more or less practicable, have been recommended for collecting the CO_2 snow and moulding it into masses of suitable shapes and sizes prior to applying it to the skin.

When drawing off the CO_2 the cylinder must be in such a position that the carbonic-acid gas comes out in a liquid state, therefore the cylinder must either be placed vertically, with the valve end pointing downwards, or on its side, with the valve end at a lower level than the other. By that means the liquid CO_2 falls to the valve end of the cylinder and comes out when the valve is opened. If the cylinder be placed with the valve end uppermost and the valve opened, only carbonic-acid gas escapes.

Small cylinders are quite easily kept in the vertical position by placing them in a stand with their nozzle end downwards, but larger cylinders are too heavy for that, and are best placed on their side with a small wooden block under the valve end and a larger block under the other end. As the cylinder empties it requires to be more and more tilted up, so as to make the liquid flow towards the nozzle. If it is desired, for convenience in drawing off the CO_2, to have the nozzle end of the cylinder uppermost, then the cylinder must be fitted in its interior with a central tube which reaches down almost to the bottom. The central tube acts like a syphon, and allows the CO_2 to come out at the top in a liquid form.

The valve is not the same in all cylinders. Some have the orifice of the valve at the end of the nozzle with the key at the side, others have the key at the end and the opening of the valve projecting from the side of the nozzle.

Pusey, to whom we are indebted for the introduction of this method of treatment in a practical form, collects the snow in a piece of chamois leather. When drawing off the CO_2 it is well to wear a pair of thick gloves. The chamois leather is wrapped round the end of a cylindrical object, such as a ruler or test tube. The ruler or test tube is withdrawn, leaving a cavity

open like a bag at one end only. The opening must be large enough to fit over the orifice of the valve of the carbonic-acid cylinder. The folded chamois leather can be held tightly on to the nozzle of the CO_2 cylinder with the left hand, whilst the key of the valve is manipulated with the right, or it may be fixed firmly on to the nozzle with a bandage which is passed over the chamois leather and fixed by several turns on to the CO_2 cylinder. Having thus fixed on the leather, the valve of the cylinder is turned till the carbonic acid escapes, which it does with a hissing noise. The CO_2 should be allowed to come out in short rushes and not continuously. The valve is repeatedly closed and opened, allowing the escape of a little liquid CO_2 each time. This CO_2 solidifies on the inner surface of the chamois leather, and the bulging of the chamois leather can be felt as the CO_2 escapes into it, and after a little experience one soon knows when it is filled. The chamois leather is then removed, and before unwrapping it, it is well to squeeze it gently so as to mould the snow together. It is then unfolded and the solid CO_2 removed by forceps or in a spoon and placed in a mould.

Instead of using an ordinary piece of chamois leather for collecting the snow, as described, it is more convenient to make an elongated bag of

chamois leather about 4 or 5 inches long, with a purse-string opening. The bag is opened and placed over the nozzle of the CO_2 cylinder and the string drawn tight. The valve is turned on and the CO_2 snow collected in the bag.

In order to get the CO_2 snow in masses of a definite shape and size, it must be pressed firmly into moulds. Pusey uses sections of hard rubber tubing about $3\frac{1}{2}$ inches long, packs the snow into these and rams it firmly down with a wooden stick or the blunt end of a lead pencil. If it is desired to have the snow very hard, a hard wooden or metal rod and a hammer should be used. When the snow is thoroughly pressed together it is removed from the mould and applied to the skin. It may be held in forceps, or better still, wrapped round with lint or cotton wool, leaving one end projecting, and applied to the area to be frozen. If the snow is firmly pressed together the stick of CO_2 can be cut with a penknife into any shape desired. For treating very small lesions the snow must be very well pressed together and then carefully pared to a point before applying to the skin.

An ordinary vulcanite or metal ear speculum makes a very good mould. Place the speculum on the table with the broad end uppermost; put in some CO_2 snow

and ram it well down with a pencil or glass rod. Do not put too much snow in at once, as it will become firmly compressed at the upper part and still remain loose at the lower. Small quantities should be put in at a time, and each quantity firmly pressed down before the next is added; thus the speculum is filled with a firm, uniformly solid mass of snow. On the outer surface the speculum becomes covered with rime, due to the condensation of moisture from the atmosphere. Turn the speculum upside down and place the warm fingers on the outer surface; that causes the formation of some CO_2 gas between the solid mass and the mould, and the cone of solid CO_2 can be readily shaken out. A conical mass is very convenient, as the pointed end can be used for small lesions and the broad end for larger ones. Specula of different sizes can be used, according to the size of the lesion to be treated. Instead of a speculum a conical minim glass does quite well, but has the disadvantage that it is apt to crack.

For treating small lesions a circular or conical stick of CO_2 snow does very well, but where there is a large area to be treated, *e.g.* a large nævus or patch of lupus erythematosus, a round stick of snow is not convenient, as it leaves untreated areas between

each area frozen. To avoid that, square sticks are advisable. The accompanying photograph shows a set of square moulds which I have found very convenient. The apparatus is made of wood and opens out on a hinge into two parts. Each half is grooved, so that when the apparatus is closed there are three square moulds of different sizes. To use the apparatus, close it, fix the metal clasp on and push it firmly down, so as to keep the two halves in contact. Fill the mould, of the size desired, with CO_2, ramming it down with a wooden or glass rod. When full remove the metal clasp, open the mould, and remove the square stick of CO_2. Such sticks may be used either by applying the square end to the area to be frozen, or, if very large areas are to be treated, by laying the side of the stick against the skin and freezing it in strips. A large area can thus be treated regularly all over.

Sutton's Method

Sutton, in America, collects the snow in chamois leather in the ordinary way, and then presses it into cylindrical moulds made of German silver with funnel-shaped tops. The mould is held with the funnel-shaped end uppermost, and the CO_2

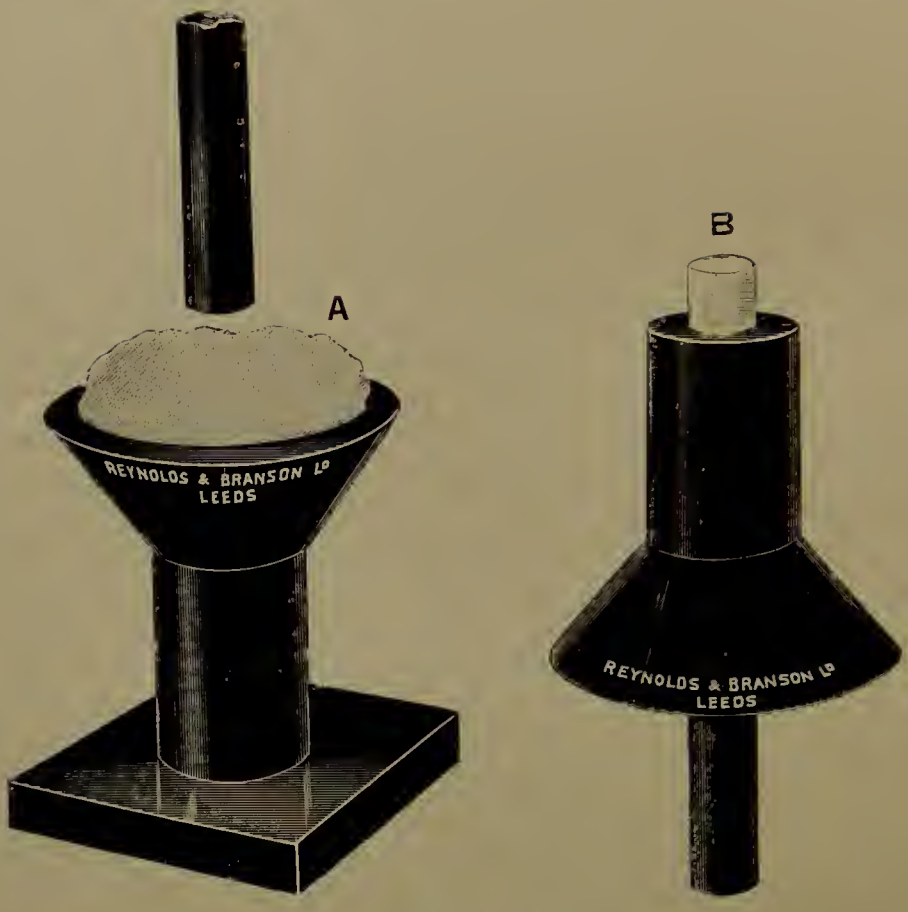
PLATE I.

THE AUTHOR'S MOULD.

Apparatus Closed.

Apparatus Open.

PLATE II.



FUNNEL-SHAPED MOULD.

snow put in and pressed down with a rod into the cylindrical part below. This mould has the advantage over the simple cylindrical ones that the snow is not so apt to fall over the edges before it has been firmly pressed down.

An apparatus which is almost identical with that of Sutton's has been recently put on the market in this country.[1] The illustration sufficiently describes these moulds. They are made in various sizes from $\frac{1}{8}$-inch to $1\frac{3}{4}$ inches, both round and square. The mould may be used as an applicator, the requisite pressure being obtained by the plunger. If so used, the stick of snow should be made to project beyond the end of the mould, so that the mould itself does not touch the skin.

M'Leod's Method

M'Leod collects the CO_2 snow in a piece of baize folded into a conical-shaped bag about 9 inches long, and uses moulds like ear specula with funnel-shaped ends. He keeps the CO_2 stick in the vulcanite mould, and presses it down on to the tissues with a plunger. In such moulds, which are conical at their upper part, care must be taken that the CO_2 is only in the cylindrical part of the mould and not

[1] By Messrs. Reynolds & Branson, Ltd., Leeds.

in the upper conical part. If the whole mould is filled up with the snow, no amount of pressure will make the CO_2 mass project at the lower end, because the stick is broader at the top than at the bottom. If the CO_2 is kept inside a mould whilst it is being applied, the mould must be a cylinder and not a cone.

Hubbard's Apparatus

Hubbard recommends a special apparatus for collecting the snow. He uses a piece of brass pipe of a diameter large enough to fit round the orifice of the valve. This piece of brass pipe is cut longitudinally into two halves, which are united at the side with a piano hinge. The pipe is perforated and is covered with chamois leather on both surfaces. The leather is longer than the piece of brass piping, to allow of its being turned over so as to close the end.

In order to use the apparatus, put a little cotton-wool in the end of the piping and turn the projecting chamois over it. Place the other end over the orifice of the valve. In order to prevent any escape of CO_2, a piece of cotton-wool is wrapped round the projecting orifice of the valve and the open end of

the piping pressed on to the orifice. The valve is then opened and the CO_2 allowed to escape, at first slowly, and later more rapidly. When fine flakes of snow begin to blow through the chamois covering the holes in the apparatus, that is a sign that it is full. The snow can then be either moulded as it lies in the apparatus or removed and pressed down into iron or brass pipes of various sizes.

Morton's Method

Morton uses an even simpler method, very similar to that first recommended by Pusey. He takes a cylindrical ruler of about 1 inch in diameter and a towel. He folds the towel lengthwise into three or four, according to the length of stick which is desired, and rolls it as tightly round the ruler as possible. He withdraws the ruler and has a hollow, porous cylinder. Into one end is placed a loosely-fitting cork; the other end is applied to the outlet of the cylinder. An ordinary bandage (4 inches wide) is then wound first round the towel and then bandaged firmly on to the valve. The CO_2 is then turned on and allowed to escape till the towel feels hard and solid and the gas blows out through the towel and bandage. On removing the bandage and

towel a large crayon of snow is ready for use at once. Morton recommends this method where a great many cases have to be treated at once, but for a single small case it is not necessary to bandage the towel on at all; simply let enough CO_2 escape into the towel and transfer it into smaller metal moulds.

Hutchins uses the barrel of an old glass hypodermic syringe with the end caps removed. Round one end of the barrel of the syringe is placed an india-rubber band. This end is slipped on to the orifice of the nozzle, whilst the other end is loosely plugged with cotton-wool. Chamois leather is wrapped round the syringe, and the whole held by a wooden clamp to prevent the fingers being frozen. The barrel of the syringe is filled with CO_2, which is pressed down by the piston. The plug of cotton-wool is removed from the end, which is applied to the part to be treated, the desired pressure being exerted on the piston.

Fabry and Zweig also recommend the use of a syringe for applying the snow. They draw off the snow into a leather bag, and then mould it into the barrel of the syringe, and press the stick of CO_2 on to the skin by means of the piston.

For treating large areas Hutchins uses a hollow wooden cylinder, ½ to 1 inch in diameter and 1 inch long. This is placed over the nozzle of the carbonic-acid cylinder and firmly fixed on to it by means of adhesive plaster. The open end is plugged with cotton-wool and wrapped round with chamois leather. The snow is collected in this and pressed down with a wooden piston of the proper size.

Graham Little makes use of a slight modification of methods already described. He winds a piece of porous filter paper round a pencil or ruler, according to the calibre of stick desired. When the pencil or ruler is removed he has a cylinder of filter paper, which is then closed at one end by folding the paper over. The whole paper cylinder except the orifice is now covered with a bandage, the open end applied to the nozzle of the carbonic-acid cylinder and tied to it by the ends of the bandage. This receptacle is filled with CO_2 snow, which is transferred into a glass tube of which the lower end is plugged with cotton-wool and rested on the table, whilst the snow is tightly packed down with a suitable wooden rod. The stick of CO_2 is removed from the mould, wrapped in cotton-wool, and applied to the skin.

Hall-Edwards's Apparatus

Hall-Edwards has devised an apparatus which, he claims, is more satisfactory and less wasteful than those already described. The apparatus consists of a collector and applicators. The collector consists of a cylinder of perforated sheet zinc or tin, inside which is another cylinder of copper-wire gauze. Between the two is a layer of felt. The complete tube is about 8 inches long and $1\frac{1}{4}$ inches in diameter, and is fitted at its upper end with a brass ring which fits tightly on to a special brass nozzle which is fixed on to the carbonic-acid cylinder. The lower end has another brass fitting over which can be attached, by means of a bayonet catch, a vulcanite mould. The open end of this vulcanite mould is closed by a vulcanite plug whilst the snow is being collected. The collector has a leather, hardwood, or vulcanite covering to prevent the hand coming into contact with the cold metal.

To obtain the CO_2 snow the vulcanite mould is fixed on to the one end of the collector, whilst the other end is held firmly on to the brass nozzle on the CO_2 cylinder with the left hand; with the right hand the key is turned and the snow allowed to escape into the collector. When sufficient snow

PLATE III.

Hall-Edwards' Apparatus.

Collecting the CO_2 Snow.

Moulding a Stick of CO_2 Snow.

has been gathered the collector is detached from the nozzle and a long wooden or vulcanite rod, which fits the lower end, is passed down the centre. The snow is detached from the sides of the collector and pressed down into the vulcanite mould by the rod. When the snow has been sufficiently tightly packed down, the vulcanite plug in the end of the mould is removed and the compressed tablet of CO_2 is pushed out through the opening by means of the rod. If another tablet of snow is required the vulcanite plug in the orifice of the mould is replaced and the process repeated. If the collector has been filled with snow, there is sufficient of it to make as many as a dozen tablets of CO_2. The tablets can be made of any thickness. Hall-Edwards uses them about a quarter of an inch thick.

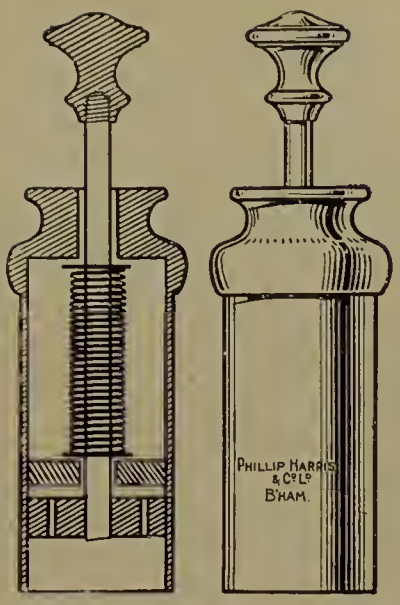
If the upper end of the collector be corked, the snow will keep for about two hours, so that it can be easily transported to a patient's house, and thus the necessity of carrying the heavy CO_2 cylinder avoided.

Hall-Edwards has also devised an applicator by which the pressure exerted in applying the snow can be regulated. It consists of a vulcanite tube, the lower edge of which is bevelled so as to make it thin at the extremity; at the other end is a

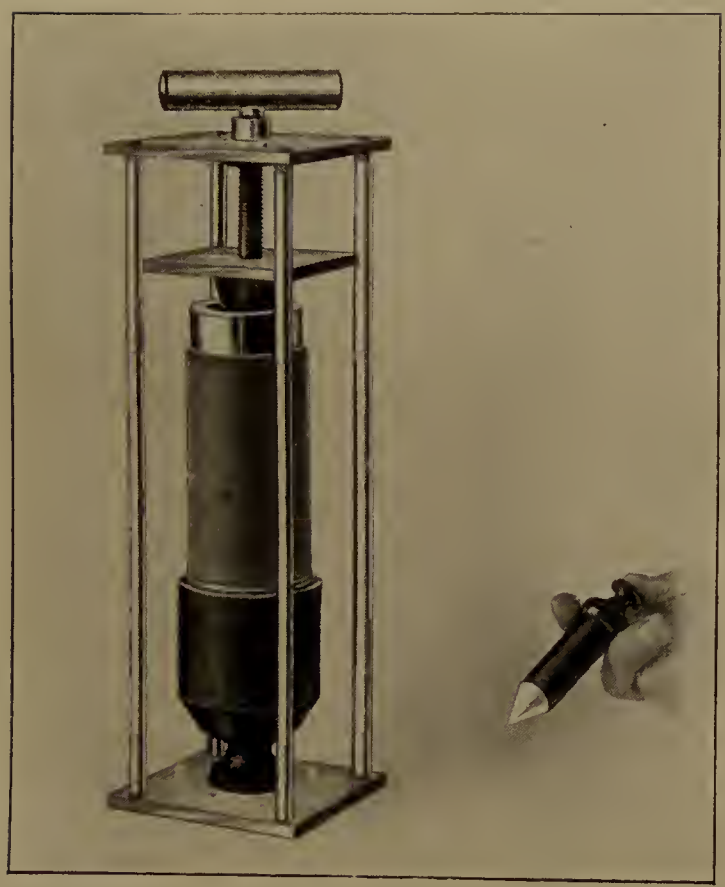
metal collar which guides the plunger. The plunger is kept at a distance of $\frac{1}{4}$-inch from the end of the tube by a spring (see illustration). It is perforated to allow of the escape of gas, and by pressing on the knob at the end of the piston it can be brought to a level with the end of the tube. The applicators are made of three sizes to hold tablets of CO_2 snow, 1 inch, $\frac{1}{2}$-inch, and $\frac{1}{3}$-inch in diameter. To fill the applicator press the open end down on a CO_2 tablet. If the tablet is already the correct size it takes up the whole of it, if larger it cuts out a circle of the required size. The apparatus can also be designed for square tablets, if necessary. To apply the snow hold the applicator in the fingers and press down the knob with the thumb.

Although the above instrument may be very convenient for applying the snow, I doubt whether it is advisable to use such an apparatus at all. One has a much better idea of what pressure is being exerted on the skin if the CO_2 is wrapped up in some non-conducting material, *e.g.* lint, and held in the fingers. With an applicator one is apt to press the tube of the apparatus too firmly on the skin, and it becomes difficult to know exactly how much pressure is being actually exerted by the CO_2

PLATE IV.



HALL-EDWARDS' APPLICATOR.



HALL-EDWARDS' COMPRESSOR AND APPLICATOR.

The compressor has a screw-clamp on which the collector and plunger are placed. Pressure is brought to bear on the CO_2 snow by the hand screw. By that means the snow becomes so firmly compressed that it is nearly transparent, and sinks in water. To the right of the picture the applicator is seen ready for use.

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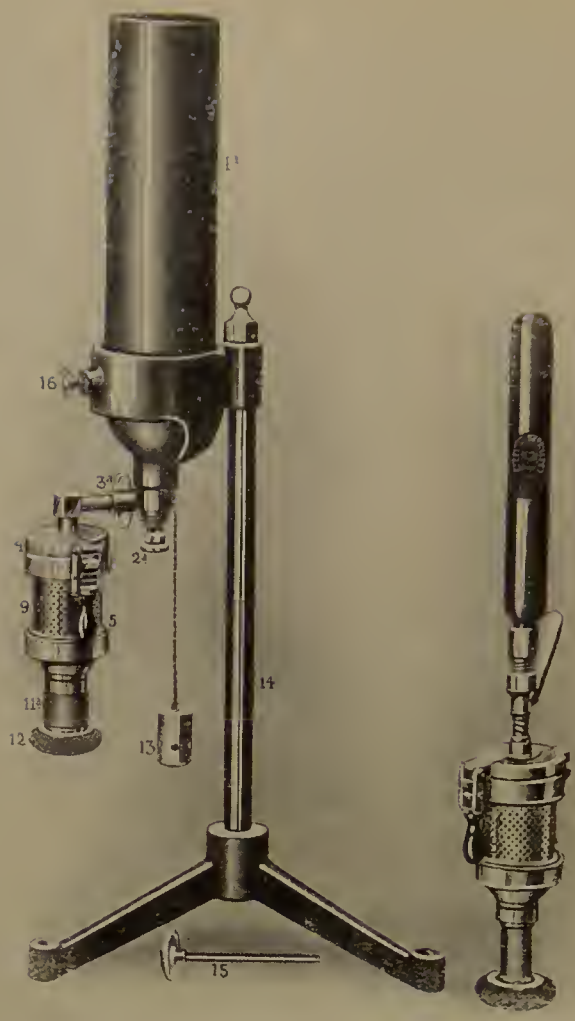

FIG. 1.

FIG. 2.

FIG. 3.

THE "PRANA" HOSPITAL APPARATUS.

snow itself; therefore on the whole an applicator seems to me to possess greater drawbacks than advantages.

The Prana Carbon-Dioxide Snow Apparatus[1]

This apparatus consists of a collector and a series of moulds of different sizes. Its construction is easily understood from a study of the accompanying illustrations. The apparatus is made of metal, and the collector is perforated and lined inside with canvas cloth. At the one end is an arrangement whereby the collector can be fixed to the CO_2 cylinder, and at the other end is the mould. To use the apparatus take the collector (9) and fasten the cover (4) to it by passing the hook hinge (6) under the hinge pin (7), shutting the closing lever (5) on to the catch (8) so that the handle of the closing lever points downwards. That closes the one end of the collector. On to the other end screw the mould (11), which consists of metal covered with indiarubber, and on to the bottom of the mould screw the cap (12). These should not be too tightly screwed on, otherwise they are difficult to unscrew later. To the cover at the upper end of the collector

[1] Made by Ærators, Ltd., London.

is attached a metal tube bent at a right angle. This metal tube is fixed on to the nipple of the CO_2 cylinder by screwing the nut (3*a*). The apparatus is now ready for use. Open the screw valve (2*a*) slightly at first, so as to let out only sufficient CO_2 to reduce the temperature of the apparatus. The CO_2 should be emitted slowly at first, and intermittently by opening and closing the screw valve repeatedly. In order to see whether sufficient snow has collected, raise the closing lever and examine the inside of the apparatus as seen in Fig. 3. The crust of snow which forms immediately under the cover should be broken through with the end of the spatula. If sufficient snow has not been formed, fix the collector again on to the cover and let more CO_2 escape. A little experience soon enables one to judge when sufficient CO_2 has been emitted. When going through the above manipulations it is advisable to wear gloves to protect the hands against the extreme cold.

The collector now contains the CO_2 snow. Detach the collector, etc., from the cylinder by raising the closing lever (5), and the snow will be seen to have collected inside the cage and to have formed a crust over the top of it just below the cover (Fig. 3). Hold the cage by the insulating material round the

PLATE VI.

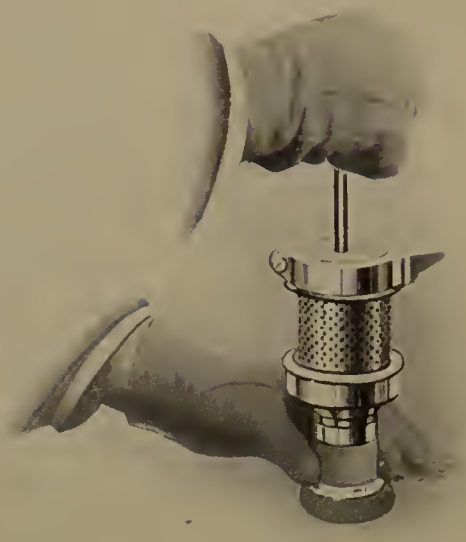

Fig. 4.

Fig. 5.

Fig. 6.

The "Prana" Collector and Mould.

mould with one hand, and with the spatula in the other break through the crust of snow at the top and ram down the snow collected in the cage into the mould, scraping the snow off the inside walls of the cage (Fig. 4). Repeat this till the stick of CO_2 snow thus formed has reached the top of the parallel part of the mould. If the mould be filled further up, the stick cannot be removed from it. Then unscrew the cap (12) from the end of the mould and insert the end of the spatula inside the collector and push out the stick of CO_2 (Fig. 5). There will be no difficulty in pushing out the stick unless it has been made too long and is conical at its upper part. In that case scrape round the bottom of the cage with the spatula so as to break off this conical part, and the stick can then be easily pushed out. The stick of CO_2 can be now wrapped in lint and applied to the skin. The square moulds make a stick of $\frac{1}{2}$-inch or 1 inch square. Round moulds of corresponding sizes are also made.

The above apparatus is the one intended for use with the ordinary CO_2 cylinders, and is known as the "hospital apparatus." There is, however, another and similar "portable" apparatus which is very convenient where it is desired to take the

CO_2 to the patient's house. The collector and moulds are the same as in the "hospital apparatus," with the exception that the cover of the collector has a straight tube for fixing on to the "gaskette." The gaskette (Fig. 7) is just a miniature CO_2 cylinder, and looks not unlike a policeman's baton. At one end it has a protective wooden cap which is unscrewed before use. This gaskette is screwed on to the union on the cover of the collector, care being taken not to depress the valve lever. The apparatus should now be rested on the table with the opening of the gaskette pointing vertically downwards (Fig. 8), so as to ensure the CO_2 being emitted in the liquid form. The valve lever is gently pressed inwards and at once released again. This is repeated at intervals of one second. The complete discharge of the gaskette is indicated by the gradual subsidence and final cessation of the rush of gas. The closing lever is then released and the collector found to be filled with CO_2 snow (Fig. 9). The further manipulations are exactly the same as already described when using the larger CO_2 cylinder.

PLATE VII.

FIG. 7.

FIG. 8.

FIG. 9.

THE "PRANA" PORTABLE APPARATUS.

Choice of Method

From the foregoing descriptions of the different methods of obtaining and moulding the snow it will be seen that though they have each been described separately, yet they are all more or less similar. For all practical purposes the simple method, with a bag of chamois leather and a series of square and round moulds such as have been described, is quite sufficient. The more elaborate apparatus, such as Hall-Edwards' and the Prana are not in the least essential. They are very convenient in hospital work where a large number of cases requires to be frozen at once. By fitting very accurately on to the CO_2 cylinders they prevent the waste of CO_2 which is bound to occur when chamois leather is used, but the leakage with the latter method is slight, and after all the CO_2 is not expensive. I have no personal experience of the Hall-Edwards' apparatus, but can vouch for the reliability of the Prana apparatus. The gaskettes, although more expensive in use than a large CO_2 cylinder, are also very convenient when it is necessary to treat patients at their own houses.

When CO_2 snow is very firmly pressed together it will keep for an hour or two if wrapped up in lint

or cotton-wool. It is often convenient at hospital to make a considerable number of sticks of CO_2 if several cases have to be treated. It saves time if the sticks are all made one after the other, instead of making each stick as required. In order to preserve the sticks, Mr. Alexander, chemist to the Royal Infirmary, has had special tin cans made on the principle of the Thermos flask or the Dewar bulb, which is used for the transportation of liquid air. These tins have a double wall with a space between the two layers (Plate VIII.). There is a tap with a valve communicating with this space. The valve is opened and the air sucked out of the space by a suction pump, so as to create a partial vacuum. The valve is then closed. The sticks of CO_2 snow are wrapped in lint and placed in the tin and the lid put on. They can be kept thus for some hours. This method for transporting the snow is very convenient in hospital work, as the CO_2 can be drawn off and made into sticks in the laboratory and sent from there to any ward where it is required. This tin also could be used for carrying snow to patients' houses. The length of time which the snow will keep depends on how firmly it is pressed together. The harder the stick the longer it will last. If very hard sticks are desired, the snow can be battered down into the moulds with a hammer. If the snow is very

PLATE VIII.

Can for Transporting CO_2 Snow.

firmly pressed down it will sink in water; if not, it floats. The harder the stick, the more easily it can be cut to a definite shape, the more firmly it can be pressed upon the skin and the more evenly it freezes the surface to which it is applied. Morton and Bunch prefer that the stick should always be hard enough to sink in water, but that requires considerable hammering, and is not absolutely necessary in order to obtain good results.

SECTION III

EFFECTS OF CARBONIC-ACID SNOW ON THE SKIN

Now that the various methods for collecting and moulding the CO_2 snow have been described, let us consider the effect of the application of the snow to the skin. The snow has a temperature of $-79°$ C.; at $-78°$ C. it becomes carbonic-acid gas. When the snow is laid gently on the skin it produces very little effect, because there is a constant formation of carbonic-acid gas (Crook's layer), which surrounds the snow and so protects the skin, but whenever the snow is pressed down it freezes the skin instantaneously. The heat of the skin melts the snow which is in contact with it, and if the snow is kept well pressed on to the surface, fresh layers of it are always coming into contact with the skin. The snow, therefore, always maintains the same temperature. At first the frozen area is pure white in colour and hard to touch. It soon thaws out again, and the frozen part, which was depressed below the surface by the pressure used, rises

up to its former level. On the surface there appear small globules of water of condensation.

The effect produced on the skin depends upon two factors, viz. (1) the amount of pressure used, and (2) the duration of the application.

The Amount of Pressure

The depth to which the skin is frozen varies directly with the amount of pressure. If the pressure be very light the freezing is very superficial, but if firm the tissues can be frozen to a depth of one-eighth of an inch or more. The pressure is varied according to the lesion under treatment. If the lesion is a very superficial one, and it is desired to cure it, if possible, without the production of a scar, the pressure must be light, but if, on the other hand, the object of the treatment is to produce a slough, *e.g.* in treating carcinomata, then considerable pressure is used so as to freeze the lesion solid down to its very base. This is the great advantage of solid CO_2 over the freezing liquids such as ethyl chloride. These substances act by evaporating from the surface, and in so doing they abstract heat from the tissues and so produce freezing, but once the surface is frozen practically no further evaporation takes place from that area, and

therefore the freezing process goes no deeper. In the case of the CO_2 snow the snow always maintains the same temperature, and once the superficial layers are frozen, the continued firm application of the cooling agent allows of a deeper freezing. The effect of firm pressure varies with the consistence of the tissues below the frozen part. If a soft part, such as the skin of the abdomen, be frozen, the pressure causes a depression of the skin below the surface, but if the skin be over a bone, *e.g.* on the forehead, then it can be pressed between the snow and the bone, and a very much less degree of pressure is required to freeze the skin to a given depth than if the parts beneath are so soft and mobile that they give under the pressure. In considering the pressure to be used in any given case, the situation must therefore be taken into account.

When freezing a lesion where a fairly superficial action is desired, *e.g.* in lupus erythematosus, sufficient pressure should be exerted to cause a slight depression of the frozen area below the level of the surrounding skin. Where a deeper effect is desired, *e.g.* in large angiomata, the pressure must be sufficient to cause a considerable depression of the frozen skin.

The histological character of the lesion under treatment is also important. The epithelial layers of the normal skin of any part of the body except the palms

PLATE IX.

Case of Psoriasis One Hour after Freezing Small Lesions for Fifteen Seconds with CO_2 Snow.

(Note well-formed Blisters.)

and soles freeze very rapidly with CO_2, but where there is a thick, horny layer the skin does not freeze so readily, owing to the thick stratum corneum being a bad conductor. Thus, if corns, warts, or other similar horny lesions are to be treated, they will stand considerable pressure before they are completely frozen through.

The Duration of Freezing

Although the amount of pressure exerted is important, the duration of the application is still more so. The duration must be varied according to the effect desired. If the snow be pressed on the normal skin and then immediately removed, it produces a mild inflammatory reaction, with redness, slight swelling of the part, but no actual blistering. This passes off in a few days, but if the application be five seconds or more, the skin, after it thaws out, becomes red, and in five to ten minutes it is turgescent and raised slightly above the surface. A lesion like a wheal is produced. The outpouring of fluid exudate, etc., increases rapidly, and in about an hour a blister is formed. This blister gradually rises higher, becoming filled with clear, serous fluid, till in twelve to twenty-four hours a tense blister is produced.

At first the blister shows practically no redness around it. It looks very like the bleb seen in an acute pemphigus. This blister, if unruptured, generally dries up in a week or so, forming a crust which is cast off some days later. The blisters, however, are usually ruptured early, leaving a moist oozing surface, and the serous fluid coagulates, producing a crust very like that of impetigo contagiosa. In this stage there is usually some redness of the skin round the area. There is a good deal of swelling due to œdema all round the frozen area. This, of course, is most marked where the tissues are lax, *e.g.* near the eye and about the ankle. When freezing anywhere near the eye, the eye is usually closed for a day or so by this œdema, so that it is well to warn patients about it. Although the swelling round the eye is sometimes very alarming, causing a good deal of injection of the conjunctiva, it soon passes off, and I have only once seen any ill results from it. After the blister heals the skin is perfectly white and smooth, without any visible scarring. If longer applications are made the reaction is proportionately greater, the blister is larger, and takes longer to heal. If the exposure has been one minute or so, a scar is left usually at the end of three weeks when the crust falls off. Pusey states that an application of five seconds produces a reaction without blistering;

an application of twenty seconds leads to blistering and crust formation, but leaves no scar ; whereas freezing for thirty seconds produces a slight scar, and fifty seconds a distinct white scar. The scar is always very smooth, thin, and soft, and never shows any tendency to hypertrophic or keloid formation. The treated part becomes dead white in colour, but sometimes an excess of pigment collects round the edge of the frozen area, thus making it stand out more prominently.

If a very long application, *e.g.* one and a half minute or longer, be given, the whole skin is killed outright. Of course in such a case no blister can form ; at least, not on the centre of the frozen area. A blister forms at the edges, where the skin is not completely killed, but in the centre all the vessels of the skin are thrombosed, and therefore no exudate takes place from them, so that a slough and not a blister is produced.

In making applications of CO_2 snow, Pusey emphasises the importance of always timing the exposures with a watch. If that is not done the results will neither be uniform nor satisfactory.

The reaction varies with the part frozen, and is most marked where the blood supply is least, therefore shorter applications should be made to the extremities of the body, *e.g.* the rim of the ear, toes, etc.

Pusey also says that the age of the patient is important, and that young children show a much more intense reaction after short applications than do adults. The skin of a child under a year old is three or four times as sensitive to freezing as that of an adult, and therefore the duration of the application in such cases should be proportionately short. He also asserts that the skin of women, and especially thin-skinned fair women, reacts very easily, as in infants, but in all cases it is well to give a short preliminary freezing in young persons so as to gauge their susceptibility.

As in the case of the pressure to be applied, the duration of the application has to be varied with the kind of lesion under treatment. In horny lesions the application must be longer than in those where the skin is thin.

Usually only one application is made to a given area, which is not further treated by the snow till the effect of the previous exposure has passed off. This means that about three weeks must usually elapse between each application, but in order to get a very intense superficial destruction of tissue, *e.g.* in treating carcinomata, Heidingsfeld recommends that immediately after the lesion has thawed out from the first freezing it should be again immediately frozen. Thus a much better effect is obtained by two such freezings

than by one single application of a duration equal to the other two.

In making all these applications the snow is applied on a definite area for a definite time, but in very superficial inflammatory conditions, *e.g.* chronic dermatitis, etc., a stimulating effect can be produced by "ironing" the surface with the snow. The snow is lightly applied to the area and moved fairly rapidly over it. The result is a freezing for a second or two, and a reaction, without blistering, not unlike what is seen after the application of such a substance as silver nitrate in spir. ætheris nitrosi. By this method of application a large area can be treated at one time.

The Effect of X-Rays and Radium

Pusey has drawn attention to the fact that skin, which has been exposed to X-rays or radium sufficiently often to produce any permanent effect, is particularly sensitive to freezing with CO_2. He found that in a vascular nævus, which had been previously treated by radium, he could produce the same effect by applications of from three to five seconds as would be produced in an untreated case in from ten to fifteen seconds. That observation I am able to confirm. I treated a very stubborn patch of chronic seborrhœic dermatitis on the

outer aspect of the leg with several exposures to X-rays at intervals of a fortnight. The disease, which had been present for over twenty years, improved under the X-rays, but the skin was still scaly and thickened. I froze the whole area once all over with applications of thirty seconds, and the reaction produced was greatly in excess of what might have been expected. A tremendous blister was produced, which projected above the level of the rest of the skin for at least an inch. This burst and left a raw surface with, at places, complete destruction of the epithelium. Although the ultimate result was good, the reaction, with destruction of tissue and scar formation, was far in excess of what was necessary. Taking advantage of the above fact, Pusey recommends the previous use of X-rays in treating vascular nævi, because thereby shorter freezing is necessary, and therefore there is less risk of producing a noticeable scar. He explains the effect as due to the endarteritis which is produced by X-rays with the obliteration of many of the capillaries of the skin. The endothelium of the vessels is irritable as the result of the X-rays or radium, and the freezing produces an intense endarteritis, and the reaction is correspondingly great in the badly nourished tissues.

The Pain of the Applications

The great majority of the writers on the CO_2 treatment have emphasised, as one of the chief advantages of the method, its painlessness. With this I cannot altogether agree. When the snow is applied there is a momentary stinging sensation, which is followed by anæsthesia, which lasts for a short time after the snow is removed; but whilst the thawing process is going on it is painful. The pain experienced varies greatly with the individual. Some patients say it is quite trivial, and that for some time there is only a nipping sensation; others complain of itching whilst the blister is rising. Some of the patients said that the pain was fairly severe for two or three hours after the application. The pain seems to be greatest when the snow is applied to the face and head, and especially when applied to the temple and side of the nose, but in no case has the pain been very excessive. The patients all submit willingly to a second freezing. Of course the larger the area frozen the greater the irritation produced. In one case the patient, who was a female, complained of a severe headache coming on about three hours after the freezing and lasting for some hours. In her case the lesion frozen was on

the face. The pain and discomfort after freezing can be relieved to some extent by the application of compresses of water. Some recommend that it should be hot, others cold; either seems to be effective. Pusey gets the patient to bathe the part for a few minutes with warm water immediately after it has thawed, but in the majority of cases no treatment is required at all.

Practical Points in the Application

In treating small lesions the CO_2 snow is moulded or cut with a knife so as to correspond as nearly as possible to the shape and size of the lesion. In certain diseases, *e.g.* lupus erythematosus, it is well to freeze slightly beyond the edge of the diseased area. In treating crusted or scaly lesions as many as possible of the crusts and scales should be first removed, as they tend to prevent the rapid action of the snow.

When freezing small, rounded lesions a circular stick of snow is best, but where large areas have to be treated, *e.g.* in a large, pigmented mole, square sticks should be used, as the applications can be made regularly side by side without leaving any intervening areas untreated. For large areas, if the

surface is a comparatively flat one, the square stick can be laid on its side and the skin frozen in a series of broad strips; thus a large area can be quickly frozen. The applications are made close to but not overlapping each other. The part under the centre of the stick is always more thoroughly frozen than that at the edge, and after the effect of the first freezing has passed off these less affected areas are visible. In making a second application the centre of the stick should be placed on the less affected areas, so that a uniform result is obtained.

If the lesion is a large one but not uniform in character, it should be frozen in small sections. By that means each area can have the exposure and pressure appropriate to the lesion.

Where the lesion has a very irregular outline M'Leod recommends the use of a layer of thin sheet-lead cut so as to exactly fit the lesion. The piece of lead is placed on the lesion and the snow pressed on the top of it. The metal conducts the cold to the subjacent area.

In order to protect the surrounding tissues Prime uses a small piece of asbestos with an opening in it of sufficient size to expose the spot to be treated.

In order to try to get a more intense action of

the CO_2 snow, Judd and Jackson and Hubbard have recommended that the snow be mixed with ether. The snow may either be mixed up with the ether so as to produce what Pusey calls a "mush of CO_2," or the stick may be dipped in ether just before it is applied to the skin. The mush of CO_2 is applied on swabs, just as one would apply liquid air. Those who recommend it claim that the mixture of CO_2 and ether is colder than the pure CO_2, and that it freezes more quickly. Pusey, however, questions that fact. Gale and he investigated the temperature of the mixture, and found that by adding solid CO_2 to ether you can gradually reduce the temperature of the mixture to approximately that of the CO_2, but you cannot reduce it below that. The ether is simply cooled down by the CO_2, just as water is cooled down by putting ice in it. With Pusey's contention I entirely agree. Ether causes freezing of the skin, not because it, in itself, is a cold substance, but because its rapid evaporation causes a sudden absorption of heat from the skin. Therefore, before ether can produce any freezing effect at all it must absorb heat from a body which is in itself warm. The CO_2 has a very much lower temperature than the ether, and presumably the ether would not be able to withdraw any heat from it, and therefore

the ether and snow mixture would not be any colder than the pure snow.

But in any case, allowing that the ether did reduce the temperature of the snow, it could only do so very slightly and not sufficiently to make any very appreciable difference.

Pusey has tried the mixture, and in his experience it does not freeze the skin any more quickly than does the pure CO_2. The use of the mush of CO_2 and ether is also objectionable, because it is in a semi-liquid form, and by using a mixture of that kind one of the chief advantages of CO_2, viz., its solidity, is lost. If the stick is only dipped in ether before being applied the quantity of ether on the snow is quite negligible, and as the surface to which it is applied is covered by the stick of snow, no evaporation of ether can occur from that surface. In any case the action of pure CO_2 snow is quite severe enough, and does not require to be intensified. If anything, a substance which is not quite so cold would be more advantageous, because its action would be less rapid and accordingly could be more easily graduated. Therefore I do not think that the mixture of CO_2 and ether is of any advantage whatever.

The After-Treatment of Lesions Produced by Freezing

Very little after-treatment is necessary. The lesions should be kept clean, and if the blebs feel tense they should be opened aseptically, otherwise they should be left untouched. However, they usually burst in a day or two. A mild antiseptic dressing, *e.g.* zinc paste with hydrarg. ammoniat. gr. v. to ʒi., does very well to prevent infection of the surface. Pusey advises washing the area once or twice daily with peroxide of hydrogen, and on covered parts, where the clothes are apt to rub on the lesions, protecting them with a dry gauze dressing or with gauze spread with boracic ointment. He cautions against the use of antiseptic powders, which cake on the surface, allow of suppuration beneath, and so cause an increase of the scar. On the face the lesion is best allowed to crust over, and if quite dry, the crust is allowed to fall off spontaneously. If the crust remain moist, it should be treated as in impetigo.

The Dangers of the Treatment

Scarring.—Provided that the applications are made with care and discretion, there are no dangers

in the CO_2 treatment. The scar produced is always beautifully smooth, and there is no record of any hypertrophic scar formation. This is more than can be said for any other local application which has the powerful effect of CO_2 snow. The only drawback is the whiteness of the scar, and on that account applications should never be any longer than is absolutely necessary. This is important, as most of the lesions so treated, *e.g.* nævi, lupus erythematosus, etc., occur on the face. Whether these absolutely white marks left by freezing ultimately regain some degree of pigmentation I do not know.

Dangers to the Eye.—Whenever a lesion near the eye is frozen it causes a very great œdema and swelling, especially of the lower lid, so much so that the eye becomes closed for a day or two; the conjunctiva on the lids, and to a certain extent on the eyeball, becomes injected. Nevertheless, that is no contra-indication to the use of CO_2 snow near the eye. Rodent ulcers and port-wine nævi very frequently are on or very near the eyelids, and if they can be cured by freezing with CO_2 snow there is much less likelihood of ectropion from the contraction of the scar than there is after other methods of treatment. Pusey has treated several vascular nævi on the eyelids of children. He holds the lid in a pair of

broad lid forceps with a solid under blade and an upper blade which is open in almost its entire extent. No harm results so long as the eye itself is not touched with the cold forceps or the snow.

Harman and Morton have also frozen the conjunctiva of the eyelid for trachoma, and although considerable swelling of the lid resulted, the eye suffered no damage.

The swelling looks serious, and often causes the patient some anxiety. Only once have I seen any damage to the eye; that was in a case where there had been an ulceration of the cornea some years previously. The CO_2 snow was applied to freeze a lesion near the eye, and caused a very severe injection of the conjunctiva with the formation of two small corneal ulcers. The sudden hyperæmia of the conjunctiva evidently upset the circulatory arrangements of the eye, with the result that ulceration took place; therefore, if there is any sign of previous corneal ulceration it is well to be cautious in applying CO_2 snow near the eye.

Sloughing and Ulceration.—There is no danger of producing sloughing provided that the applications are not too long or too vigorous. Except where it is wished absolutely to destroy a growth, *e.g.* a rodent ulcer, the object of the treatment is to remove the

disease without producing any more scarring than is necessary; therefore, if repeated short applications are made, the same result can be gradually obtained, as regards cure of the disease, as can be obtained by one long application. The scar is also very much less conspicuous. The danger of sloughing in vascular nævi will be referred to later under that disease.

Embolism.—Theoretically this danger suggests itself as possible, especially in the treatment of large vascular nævi, but so far, neither with liquid air nor CO_2 snow, has any result of this kind ever been recorded.

Danger of CO_2 Snow Falling into the Mouth.—Pusey refers to this as a possible occurrence whilst treating nævi about the mouth of infants. No doubt considerable damage might be done to the œsophagus were the child to swallow a lump of the snow, but this risk can be guarded against by holding the child so that, in the event of a piece of the snow breaking off, it would not fall into the mouth.

Danger of the Patient Fainting.—This danger must be borne in mind, especially when treating female patients. It occurred to me once when treating a vascular nævus on the face. A considerable area was frozen in sections, and just after the

last area was frozen, and before the frozen skin had had time to thaw out, the patient felt faint. She was immediately made to lie down, but owing to the weakening of the circulation the skin took much longer to thaw out than it should have done, and therefore the subsequent reaction, with some sloughing, was much more severe than was intended. In this case I do not think the fainting was due to the pain. The patient said that she fainted under the slightest provocation. If it be thought likely that the patient will faint, it is well to make her lie down whilst the snow is applied, and if she has fainted, to apply at once to the frozen area cloths soaked in hot water, so as to help to thaw it out as soon as possible.

Carcinoma

The subsequent development of carcinoma after applications of CO_2 snow has been recorded by Janeway. His patient was sixty years of age, and had suffered from lupus erythematosus for thirty years. The disease was treated by freezing with CO_2 snow, and one patch was frozen twice as long as the others. Two weeks later there was a definite swelling at the site of this patch, and on excision

it proved to be a squamous-celled carcinoma. Janeway attributed the development of the carcinoma to the freezing, but the patient had been treated for four years previously with X-rays, and Gottheil, who also saw the case, thought that it was much more probable that the carcinoma was the result of the repeated X-ray exposures than of the freezing.

Sequeira also reports a case of a woman, aged twenty-seven, who had suffered from lupus erythematosus for nine years. She had been treated in several London hospitals, and had a few applications of CO_2 snow, after which a carcinoma developed; but Sequeira neither states whether she had been frozen on the area where the carcinoma developed nor whether she had previously had X-rays. Sequeira did not blame the CO_2 for its production, therefore I think there is no direct evidence, as yet, that carcinoma is to be reckoned as one of the possible dangers of the CO_2 treatment. In these cases it was probably a coincidence that the malignant disease should develop after CO_2 snow had been used.

SECTION IV

MICROSCOPIC CHANGES AND EXPERIMENTAL RESULTS

Liquid air and carbonic-acid snow have very much the same effect when applied to the skin. Each is applied with pressure for a given time, and produces a sudden freezing of the part. On the other hand freezing, by spraying ether or ethyl chloride on the skin, is a more gradual process and not such a deep one.

A considerable number of workers have investigated microscopically the changes produced by refrigeration. The early experiments were done with ether and ethyl chloride, the later ones with liquid air and CO_2 snow.

These early experiments, although not exactly comparable with the later ones, yet afford valuable information with regard to the changes produced by slight or repeated refrigeration.

In using CO_2 snow the object of the applications is to produce, either a sudden "shock," from which the tissues more or less recover, or complete death

of the part. In the case of lesions of a non-infective nature, such as vascular nævi, one or other of these effects is produced. Further, in the case of diseases due to specific infective organisms the effect of the snow on the infecting agent must be taken into account. It will conduce to clearness, therefore, if, in the first instance, the effect of CO_2 on micro-organisms is studied.

Bactericidal Action of CO_2 Snow

Part of the effect of CO_2 snow, as it is applied to the skin, might be due to the carbonic acid as such, because the snow is always giving off carbonic-acid gas.

Fink, in discussing the effect of CO_2 snow on trachoma, endeavours to explain its healing properties on the ground that the infecting virus, which is very resistant to most remedies, is unable to exist in the presence of the CO_2 snow. He refers to Hankin's researches on the effect of soda-water on the spirillum of cholera. Hankin showed that this organism cannot live in water containing carbonic-acid gas, and that in infected districts it is safe to drink water which has been ærated with carbonic acid and allowed to stand for one week. Lewis has

shown that carbonic-acid gas can inhibit the growth of freshly inoculated cultures of the cholera spirillum, but both Lewis and Porter found that it had no effect on the virulence of cultures which had grown for some time. Porter also found that the tubercle and tetanus bacilli were not in any way affected by the gas.

Obviously the carbonic acid, when applied as snow to the skin, could only come into actual contact with any organisms which happened to lie on the surface, and even then its effect, if such exists, would be of very short duration. I think, therefore, that we must conclude that the carbonic acid as such has no bactericidal effect.

The next point to decide is whether the application of intense cold for a short time has any effect on the life or growth of organisms. The first experiments to determine this point were carried out by Campbell White. He kept living cultures of various organisms, *e.g.* anthrax, diphtheria, and typhoid bacilli, at the temperature of liquid air for a given time. The cultures were put in sealed tubes, which, to prevent fracture, were first cooled down by solid carbonic acid and then put in liquid air. Even although such organisms were kept at -250° C. for a considerable time, on sub-culture they grew quite as well as

before. These results have been confirmed by Macfadyen and Rowland, who used cultures of several organisms, including staphylococcus, diphtheria bacillus, and cholera spirillum. These last observers found that such organisms still grew even after being kept for a whole week at the temperature of liquid air. Wolff, Meyer, Dewar, and Beckett also obtained similar results.

These experiments, therefore, prove conclusively that the mere keeping of a skin lesion for a few seconds at a low temperature, such as that of CO_2 snow, cannot have the slightest injurious effect on any organisms which may be present.

We are consequently forced to the conclusion that any effect which carbonic-acid snow may have on diseases due to specific organisms cannot be directly due either to the carbonic acid as such or to the temporary lowering of the temperature. The effect in such cases must be due indirectly to the inflammatory reaction which is set up by the application of the cold substance. The reaction in the tissues must stimulate them to attack and throw off the invading organism.

The Changes Produced in the Skin by Freezing

The changes produced must naturally vary with the duration of the freezing. Immediately after the normal skin has been frozen with CO_2 snow and allowed to thaw, a slight redness appears, and in from ten to fifteen minutes the area becomes pale and slightly raised like a wheal. If the application has been a very short one of less than five seconds, the process goes no further, the skin gradually returning to the normal in less than a week; but if the application has lasted twenty seconds, the wheal-like lesion is replaced in about two hours or so by a blister, which contains clear yellowish fluid. At first this blister shows practically no redness around it. It gradually becomes more tense and may rupture. After rupture fluid continues to ooze from the surface, and if left alone the surface becomes covered with a yellowish crust not unlike that seen in impetigo contagiosa. This crust drops off in from fourteen to twenty-one days, leaving the area white but without any scar.

If the freezing is thirty seconds in duration a similar blister is produced, followed by crusting. The

crust takes slightly longer to separate, and when it does so a very slight superficial scar remains.

If an application of sixty seconds or more be made, a very tense blister rapidly forms. After rupture it is seen that in the centre of the base of the blister the true skin is exposed, the whole of the epithelium having sloughed off. A healing sore results which granulates, and eventually in three or four weeks heals over, leaving a smooth white scar.

Whilst the effects just described are the usual ones, the reaction to freezing varies somewhat in different individuals. I have seen sloughing produced on the leg of a female patient after an application of ten seconds with only medium pressure; but on the whole, allowing for differences in the age and sex of the patient and in the position of the area, the results are fairly constant.

Microscopic Changes

Juliusberg examined the human skin microscopically after freezing with CO_2 snow. He froze an area of normal skin for thirty seconds, and twenty-four hours later cut it out. Marked changes were present in all the layers of the skin. In the epithelium the

nuclei did not stain except in a few cells of the basal layer. Under the epithelium were collected dense masses of polymorphonuclear leucocytes, and the whole of the connective tissue of the true skin was infiltrated with these cells. The lymphatic vessels were greatly dilated and filled with homogeneous masses. The blood-vessels were dilated and surrounded by a leucocyte infiltration. Inside the vessels were thrombi which consisted either of red blood corpuscles, leucocytes, or hyaline material. On staining with Weigert's fibrin stain, the whole connective tissue was seen to be permeated by a fine network of fibrin. The elastic tissue appeared to be unchanged.

This observation by Juliusberg only affords a limited view of the results of freezing. In order to find out the sequence of events which occur after freezing I have made a series of observations on animals. The rabbit was the animal used. Areas of skin were frozen for periods varying from fifteen seconds up to two minutes. In rabbits the changes which are visible to the naked eye after freezing are very similar to those seen in human beings; but there is one point of difference. Fabry and Zweig have pointed out that the reaction is much later in appearing, and the whole process is

spread out over a longer period of time. I froze a small area on the ear of a rabbit for sixty seconds with a circular stick of CO_2 snow, using medium pressure. Next day that area was swollen, hyperæmic, and when held near a light looked opaque compared with the rest of the ear. The swelling very gradually increased, and only on the third day did any signs of a blister appear. This blister burst after a week or so, and the area became crusted over. When the crust fell off the area was quite white and devoid of hair. The animal has not been under observation long enough to see whether the hair will grow in again, but in a rabbit similarly frozen by Fontana the hair grew in again in about two months.

This slow development of the reaction in rabbits is rather an advantage than otherwise, because it allows the various changes which occur to be more easily followed.

Juliusberg has shown that in skin which is examined immediately after it has been frozen and allowed to thaw there are no changes to be seen microscopically. All the cells, both in the epithelial layers and in the corium, stain normally. I have found that if the skin of the rabbit is frozen for thirty seconds and examined twenty-four hours later,

very marked changes are already present. These changes occur chiefly in the deepest parts of the cutis vera, and in and just beneath the epithelium. Between these two zones the changes are less marked. The deep blood-vessels of the cutis are very much dilated and surrounded by an infiltration of polymorphonuclear leucocytes. Inside some of the vessels normal blood is seen, but in others clear hyaline masses fill up the lumen. The connective-tissue fibres of the corium, especially in the deeper parts, are somewhat swollen and widely separated from each other by spaces, which evidently contained fluid. Between the fibres there is also a considerable quantity of finely-granular material which does not give the staining reactions of fibrin, and which probably consists of coagulated or precipitated particles from the fluid exudate. The nuclei of the connective-tissue cells are well stained. Numerous polymorphonuclear leucocytes are scattered diffusely through the corium, but are grouped especially round the blood-vessels and just underneath the epithelium. The accompanying photograph (Plate X. Fig. 1) shows these dense masses of leucocytes which have congregated in patches and are invading the deeper layers of the epithelium. At these points there is a commencing vesicle formation. The cells in the middle of the rete

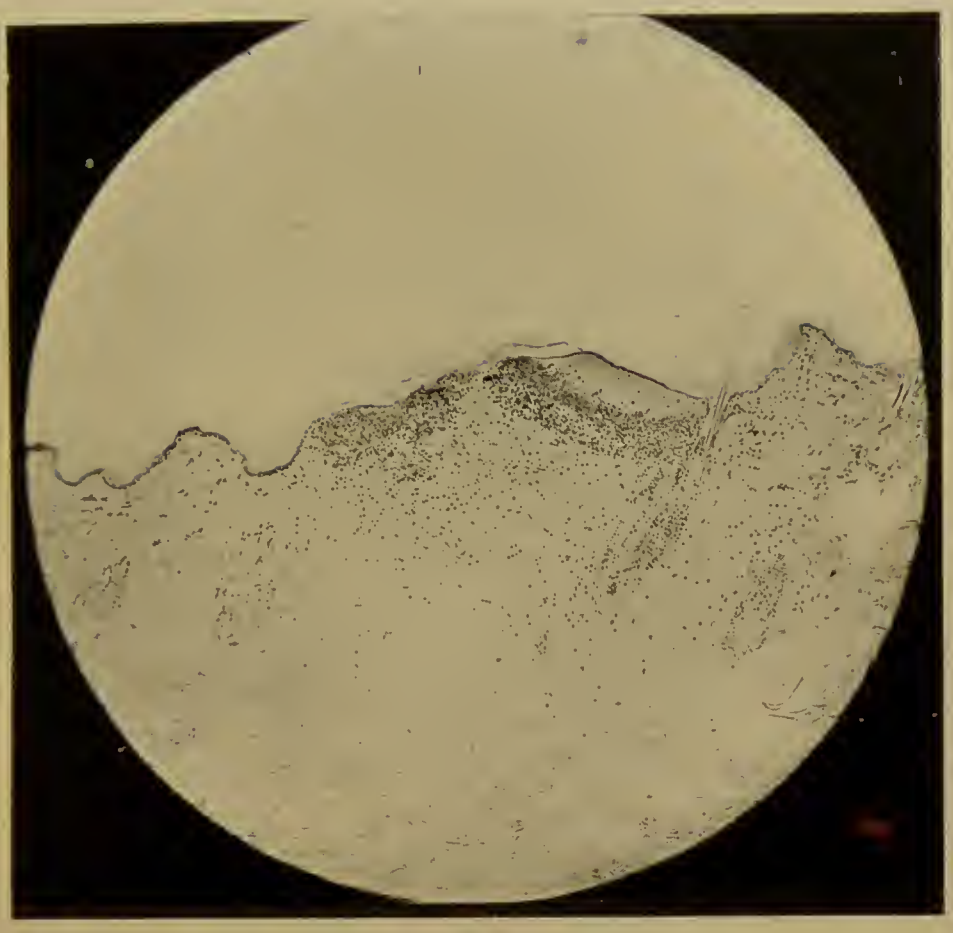

FIG. 1.—SKIN OF RABBIT, TWENTY-FOUR HOURS AFTER FREEZING FOR THIRTY SECONDS WITH CO_2 SNOW.

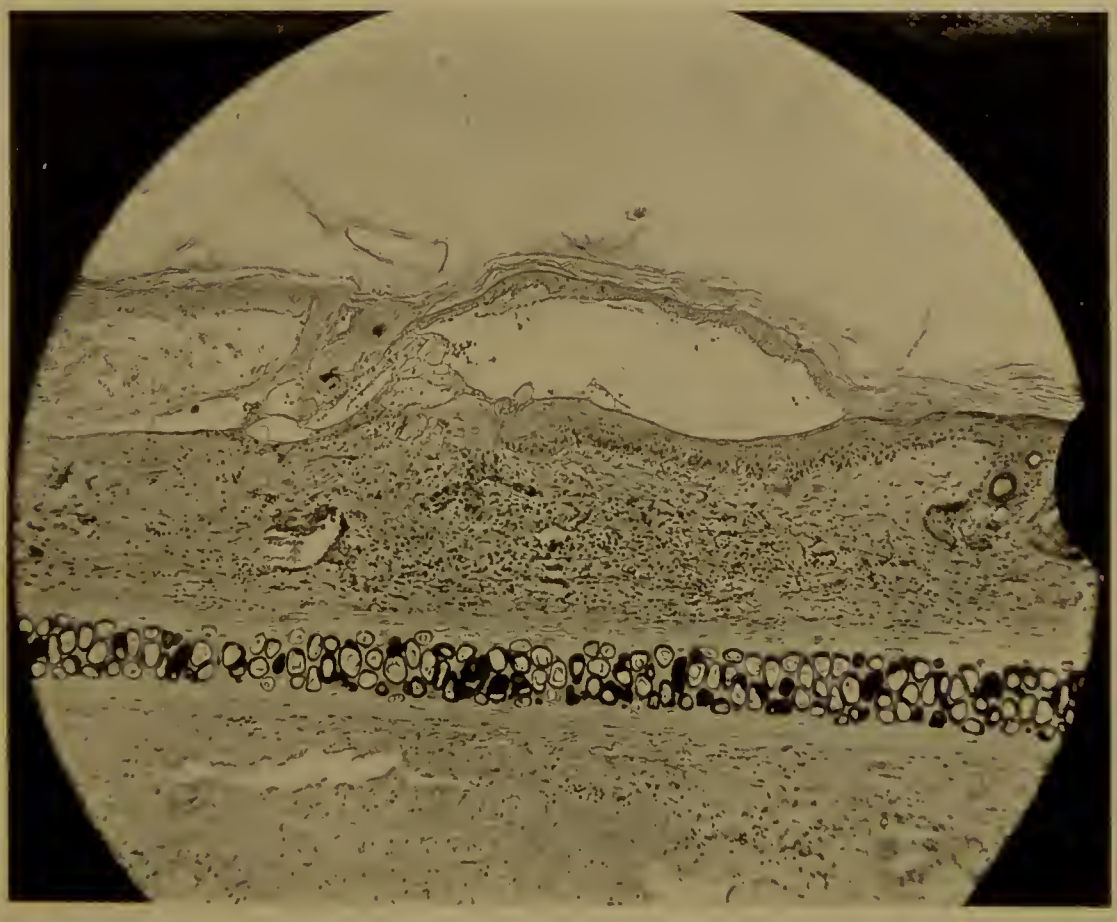

FIG. 2.—SKIN OF RABBIT'S EAR, FIVE DAYS AFTER FREEZING FOR SIXTY SECONDS WITH CO_2 SNOW.

Malpighii have lost their staining power, and the superficial layers have been raised up by a fluid exudate. Over the surface of this exudate the horny layer and part of the Malpighian layer are stretched. In the epithelium at the edges of these commencing vesicles the cells are slightly swollen and many show a shrinkage of the protoplasm away from the nucleus, which lies in a space. The elastic tissue fibres in the corium are slightly swollen but not broken up.

Fig. 2 on Plate X. shows a later stage of the reaction. It represents the edge of an area of skin from a rabbit's ear which was frozen for sixty seconds and examined five days later. The changes are best followed if the specimen be studied from the edge inwards towards the centre. At the edge the freezing was less than in the centre, and therefore there is a gradual transition from the unfrozen skin to the completely frozen area in the centre.

Passing inwards from the normal skin the first change noticed is a thickening of the epithelium. Each individual cell of the Malpighian layer is swollen, but there is no evidence of any multiplication of the cells. The granular layer is more marked than normal.

A short distance further inwards a blister is visible in the centre of the Malpighian layer. This blister has raised up the horny layer and part of the Malpighian layer, and the cells of the latter show shrinkage of their protoplasm, leaving spaces round the nuclei. Inside the blister are swollen epithelial cells, leucocytes, finely-granular material, and clear hyaline-looking masses.

Still further inwards the Malpighian layer below the blister gets gradually thinner, tapers to a point, and disappears altogether. The roof of the vesicle is now formed of all the layers of epithelium, and on following this a short distance further inwards the vesicle gradually disappears, and a necrotic unstained epithelium is all that can be seen. In this necrotic epithelial layer the nuclei of the cells are unstained. All the granules of pigment which these cells contained are, however, still visible. The horny layer is detached from the surface.

The root sheaths of the hairs show similar changes to the cells of the Malpighian layer, and can be seen tacking down the roof of the blister to the base. In the central area the root sheaths are like the rest of the epithelium, completely unstained and necrotic.

On the surface of the skin outside the blister some of the sections show a very curious condition. There

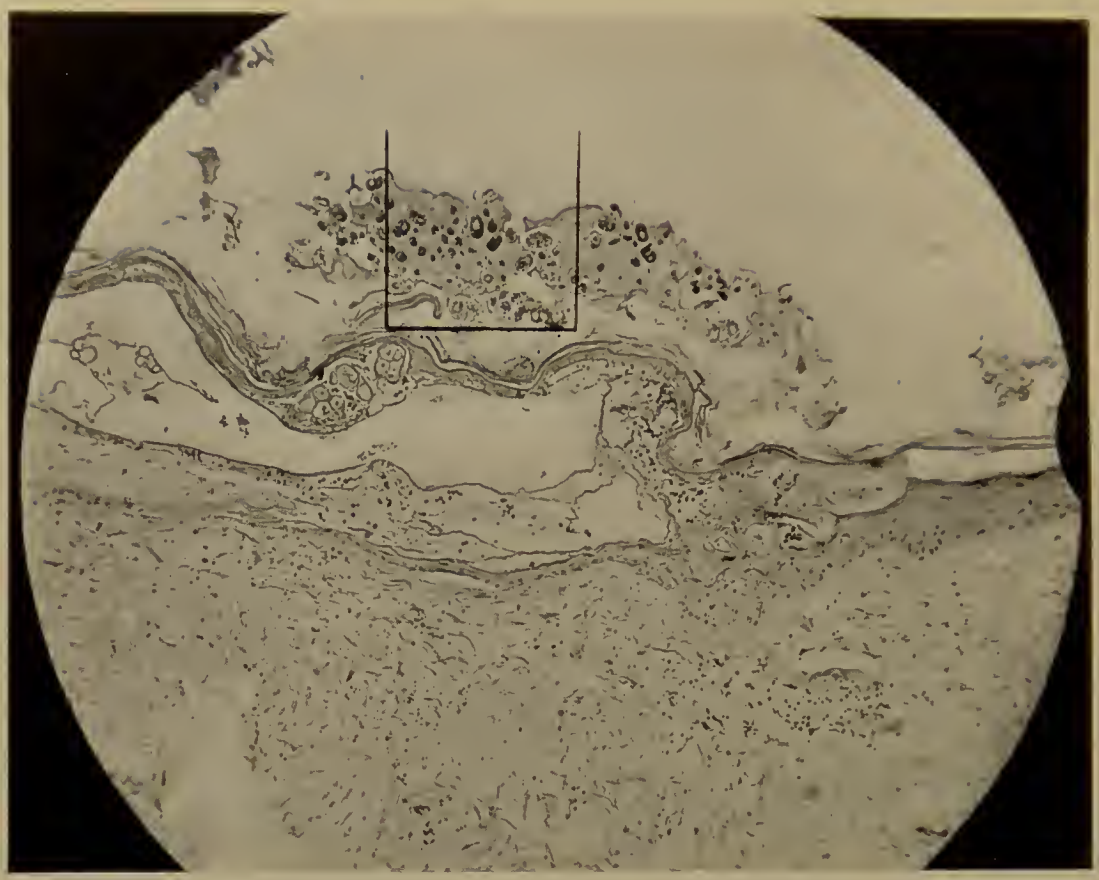

FIG. 1.—SKIN OF RABBIT, FIVE DAYS AFTER FREEZING FOR SIXTY SECONDS WITH CO_2 SNOW.

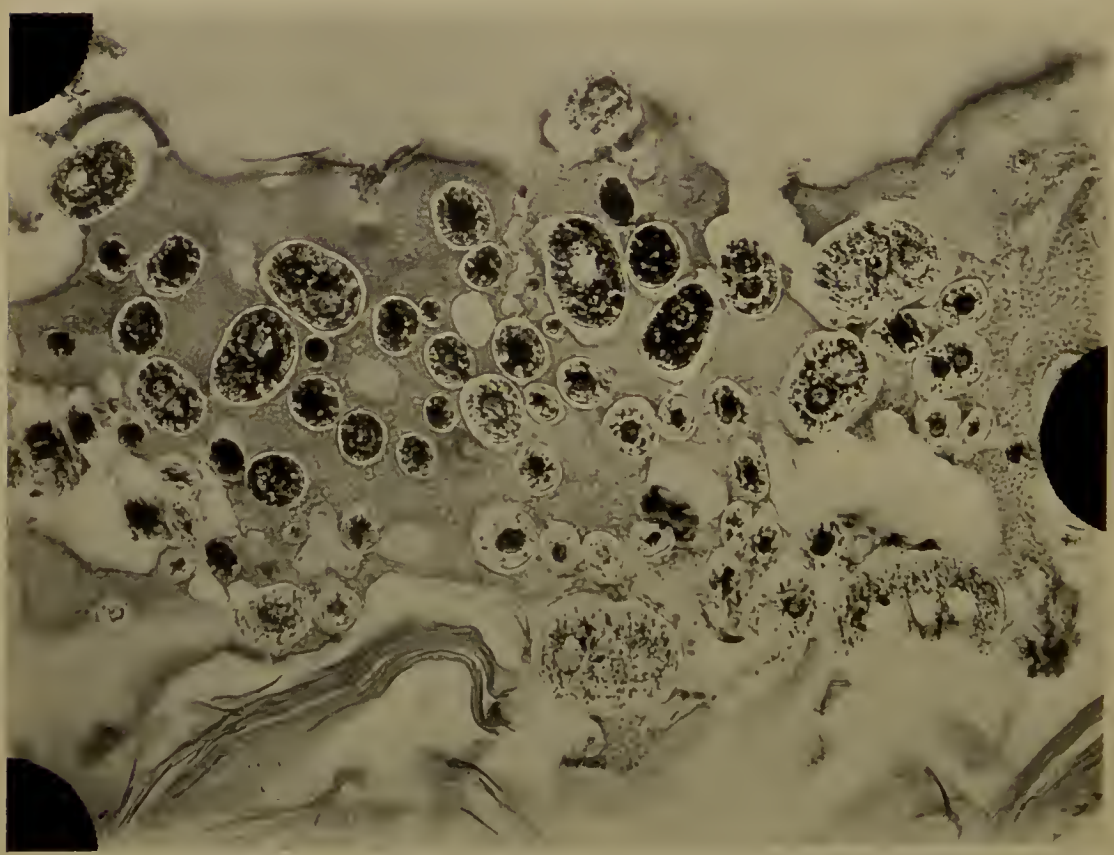

FIG. 2.—HIGH POWER VIEW OF AREA MARKED ON FIG. 1, SHOWING SWOLLEN HAIRS ON SECTION.

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is a finely-granular mass of coagulated or precipitated exudate, in which lie numerous round and oval bodies, which appear to have one, two, or three nuclei surrounded by dark brown granules of pigment (Plate XI.). At first sight they look not unlike large phagocytic cells, which have taken up pigment and been discharged on the surface when the blister burst; on closer examination, however, and comparison with other sections, these were found to be swollen hairs cut across. The oval ones are cut obliquely, and the clearer parts in the centre, which look like nuclei, are the spaces in the medulla of the hair. Their peculiar appearance is evidently due to the dead hairs imbibing fluid and so swelling up.

If the corium of the skin be examined in the same sequence as that employed for the epithelium, it is found that at the edge of the frozen area there is a zone, just under the blister, where there is very marked dilatation of the blood-vessels, œdema of the tissues, and a widespread infiltration with polymorphonuclear leucocytes. The blood-vessels contain thrombi of red blood corpuscles, leucocytes, and curious masses of swollen hyaline-looking material similar to that seen inside the blister. The connective-tissue fibres are swollen by the absorption of fluid, and separated from one another by fluid and

granular exudate. Passing inwards to the central area there is found, as in the case of the epithelium, a complete necrosis of all the tissues of the corium. They have the exact appearance of the tissues in infarction. The outline of the cells and fibres can be seen, but none of the nuclei are stained, with the exception of those of a few leucocytes which have wandered in. The blood-vessels are thrombosed, and filled in most instances with finely-granular material.

The changes which have just been described are of the nature of a reaction very similar to that seen after the application of an irritant. The epithelial layers show, from without inwards, all changes from degenerative swelling to complete cell death. At the edges where there is still circulating blood there is œdema and the formation of a vesicle, but in the central part there is complete sloughing of the tissues, and as the vessels are thrombosed there is no œdema and no vesicle formation. It is a process of dry gangrene. The central part must necessarily heal with a scar, whilst the edge, where some of the epithelium is still preserved under the blister, will heal without scarring.

Explanation of the Action of Refrigeration in Disease

After a study of these changes produced in the skin by freezing we are in a position to explain how carbonic-acid snow produces its effects in disease.

There are three factors at work :—1. Thrombosis of the vessels with the cutting off of the blood supply to the part frozen. 2. Direct injury to the tissues by the freezing and thawing. 3. Exudation of fluid and cells leading to absorption of inflammatory products.

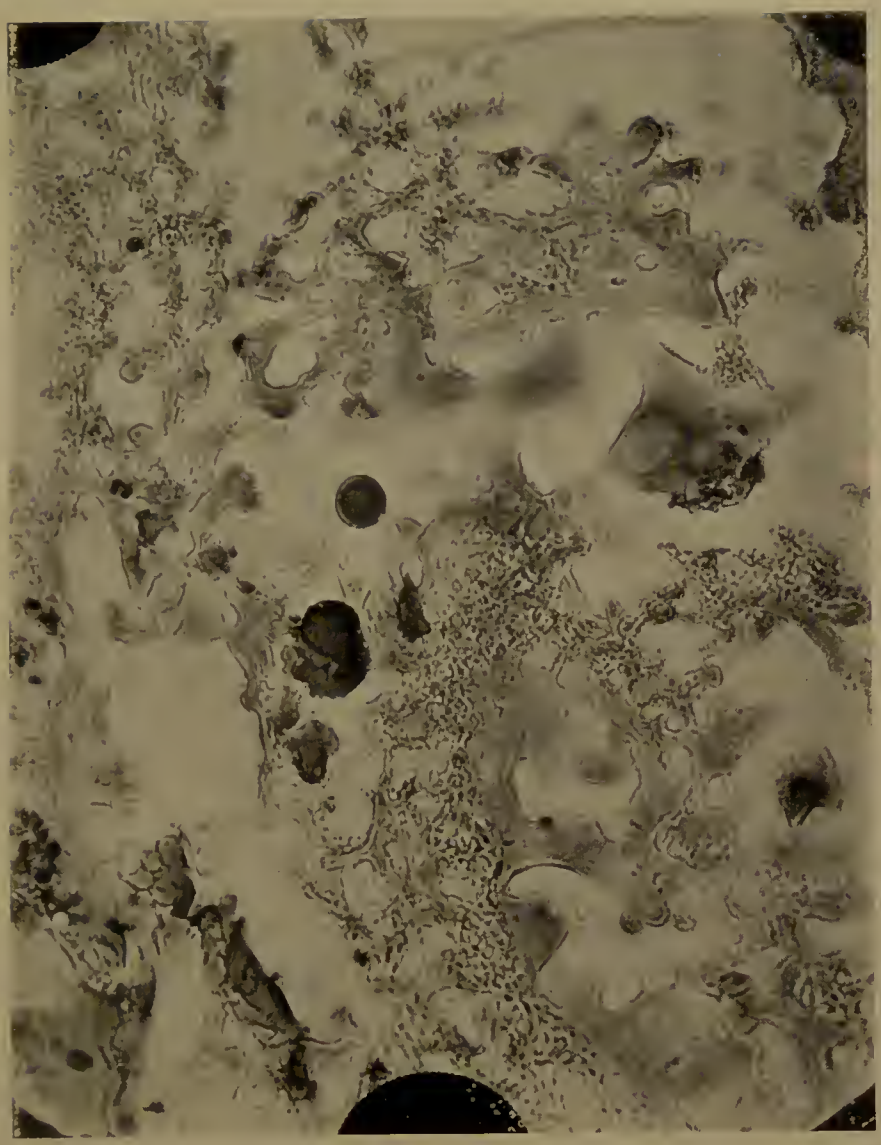
1. *The thrombosis of the vessels* is undoubtedly an important factor. There is an injury to the vessel wall, and on that injured wall thrombosis occurs. In the early stages these thrombi are finely granular, and probably consist of masses of blood platelets. A little later leucocyte thrombi are seen, or a mixture of the finely-granular and leucocyte thrombi, but in addition to these are the clear hyaline-looking masses found in the vessels. Kriege in 1889 described these in the vessels of the skin of rabbits which had been frozen by ether. He considered these "hyaline thrombi as degenerated leucocyte thrombi where the leucocytes had swollen up, lost

their nuclei, and fused into a homogeneous mass." In support of this explanation is the fact that in my sections from the rabbit's skin, where similar hyaline-looking masses were present in the vessels and vesicles (Plate XII.), leucocytes could be seen, the protoplasm of which was swollen, clear-looking, and stained exactly like the "hyaline" material.

Hodora also found similar "hyaline" thrombi in the vessels of the skin in a case of gangrene due to frost-bite, but thought that, because they stained with Weigert's fibrin stain, they consisted of altered fibrin. At present I am not in a position to state definitely what this clear-looking substance is. It does not stain with Unna's saffronin-tannic acid method or with the other special stains for hyaline. It is possible that it is simply the result of the sudden fixation of the tissues by the alcohol, and of the nature of a precipitate from the fluid exudate.

Kriege maintains that the chief effect of refrigeration is due to the thrombosis in the vessels. Uschinsky, on the other hand, considers that the effect on the disease cells is the direct result of the cold, because the superficial cells, which are most thoroughly frozen, are most affected, but that fact is also capable of explanation by Kriege's theory, because the superficial cells are furthest from the

PLATE XII.



Rabbit Skin. High Power View of Hyaline Masses Found Inside the Vesicles.

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blood supply, and therefore most easily affected when any thrombosis occurs.

2. *The direct injury of the tissues by freezing and thawing.*—Morton has suggested that the effect produced by freezing may be due to the mechanical bursting of the cells and their nuclei by the freezing and thawing. There is nothing, however, to support this. Immediately after freezing with CO_2 snow there is no visible change microscopically. If the freezing process kills the cells it must do so by depriving them of their vitality without altering in any way their physical characters.

3. *The exudate of fluid and cells* produced by freezing undoubtedly plays an important part. The whole frozen area is permeated with lymph and leucocytes. The latter by phagocytic action may remove inflammatory materials, and the former flushes out the tissues and brings fresh lymph into the inflamed area. In none of the sections were any giant-cells or other large phagocytic cell seen. Fuerst, by repeated freezing of the skin with ether, both in man and the rabbit, produced a thickening of the Malpighian layer of the skin with the formation of large multinucleated epithelial cells. These cells were only produced when the skin was repeatedly frozen at intervals. They are quite different from

the ordinary giant cell seen in inflammatory conditions.

These three factors, therefore—thrombosis, direct injury of the tissues, and the inflammatory exudate—probably all act together.

Thrombosis and direct injury to the part lower the vitality or cause the death of the abnormal cells, which are more easily injured than the normal, and the inflammatory exudate aids in throwing them off or in absorbing them.

SECTION V

THERAPEUTIC USES OF CARBONIC-ACID SNOW

There is now a considerable number of skin diseases in which CO_2 snow treatment has given very good results. Each disease will be taken up separately, those in which the treatment has been most thoroughly tested being dealt with first.

Nævus Vasculosus

Vascular nævi have been successfully treated with liquid air, so that one would expect that equally good results would be obtained by CO_2 snow. Most of those who have worked with it in such cases have nothing but praise for the method. I have treated ten cases, three of which were stellate nævi (spider nævi), one a large prominent cavernous nævus, five capillary nævi, and one mixed lesion with flat and prominent areas. With the exception of the stellate nævi and one port-wine stain the results have been good. In the more prominent

ones the results were better than in the very flat ones. For descriptive purposes it is convenient to divide these nævi into—1. Flat, non-projecting or slightly-projecting capillary nævi, and 2. Projecting cavernous nævi.

1. *Capillary nævi.*—I quite agree with Pusey and others that the flat nævi are not so easily treated as the more prominent ones. After the first application of the snow very little result is seen, and it is only after a second freezing that the result begins to be apparent. Morton has treated a great many vascular nævi of all sorts by this method. Out of 134 capillary nævi 121 (or 90 per cent.) were cured by one application, which lasted on an average forty seconds, eight required two applications, three had three applications, and two had four applications. These results speak for themselves. The duration of freezing should be short, about twenty to thirty seconds, so as to try to produce thrombosis in the vessels without destroying the skin. If one application is not sufficient, it can be repeated till the colour of the lesion is gradually brought down to that of the surrounding skin. No second application is made before three weeks or so, when the effect of the previous freezing has completely passed off. It should also be remembered

PLATE XIII.

Nævus Vasculosus before Treatment.

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PLATE XIV.

The Same Patient as in Plate XIII. Twenty-four Hours after Freezing the Lower Part of Nævus for Thirty Seconds.

that once involution of the nævus is started it tends to go on spontaneously.

Cavernous nævi.—Except in the very large ones, the treatment is satisfactory. I have only treated one very large one, which was on the scalp of a child. This was frozen three times all over, but although the superficial part improved the deeper part continued to increase in size. Other smaller and less prominent nævi on the body of the same child were cured completely after two applications.

Morton has treated fifty-one cavernous nævi, thirty-three of which were completely cured by one application, eight after two applications, three required three, and two required four applications. Five of Morton's cases were not benefited or only incompletely cured. Where CO_2 snow failed electrolysis was used. It might be thought that in freezing such large nævi there would be a risk of the thrombosis spreading to adjacent parts or of emboli being produced; so far neither of these occurrences has been recorded, and the method seems to be quite safe.

Sloughing and hæmorrhage are also occurrences which suggest themselves. Heidingsfeld records sloughing of a cavernous nævus some weeks after treatment with CO_2 snow, with the production of a

wound which healed very slowly. Pusey also reports a somewhat similar experience in treating a large cavernous nævus involving the greater part of one side of the face and scalp in a child under one year old. Half a dozen applications of the snow were made at one time over various parts of the nævus, and were followed by an intense reaction, resulting in ulceration of the entire surface of the nævus. This healed in about two months, with a disappearance of almost all of the nævus tissue, but in the scar were left numerous subcutaneous angiomata as big as hazel nuts. The contour of the child's face, which was much distorted, was restored practically to normal. Before the freezing the eye could not be opened at all owing to the amount of hypertrophic nævoid tissue on the lids. After the freezing the lids were practically normal, and the child had perfect use of the eye. Later on, the subcutaneous lesions were treated by freezing, with improvement and without any such severe reaction as occurred after the first application. Pusey considers the sloughing in his case and that of Heidingsfeld as of the same character as sometimes occurs spontaneously in such nævi. The freezing of one part starts a thrombosis, which, in Pusey's case, evidently spread throughout the whole lesion, causing a complete sloughing.

There is no necessity, therefore, in such cases to freeze the whole lesion, as the process of thrombosis, once started, spreads to other parts. The risk of hæmorrhage in such cases where sloughing occurs is more imaginary than real. The vessels being thrombosed, hæmorrhage cannot take place from them.

The treatment of small stellate nævi, which are so frequent on the face, has not proved very satisfactory in my hands. It is difficult to use the snow on them without freezing an area much larger than the lesion, and one freezing has not always been sufficient to cure them in the three cases where I have tried it. I think, with M'Leod, that freezing in such cases has no advantage over electrolysis.

Pusey recommends for nævi the combined use of freezing and X-rays. He gives X-ray exposures up to the point of producing a very slight reaction. This causes an endarteritis and makes the blood vessels much more susceptible to the action of the snow. After the use of X-rays, as already stated, the applications of the CO_2 must be very short—only about ten seconds—owing to the hypersensitiveness of the tissues to the snow. By the use of this combined method Pusey has obtained almost com-

plete disappearance of nævi with very little perceptible alteration in the skin.

The treatment of vascular nævi on the eyelids has already been referred to (p. 41).

It should also be borne in mind that as most vascular nævi are seen in children, the duration of the application must be proportionately short according to the age of the child.

The freezing method of treating vascular nævi has great advantages over the older ones of electrolysis and the cautery. It can be done without the necessity of a general anæsthetic, and is the method of choice in the first instance. Should freezing alone or X-rays and freezing not be successful, then resort must be had to electrolysis.

Bunch, Zeisler, Sauerbruch, Ito, Lawrence, M'Leod, Zweig, and Hubbard all confirm the good results reported by Pusey and Morton. Of all those who have used it, only one—Di Bernardo—thinks it is no better than the older surgical measures. M'Leod thinks that there is only one other method of treatment, viz. by radium, which is as good as the CO_2 snow. Morton, who has treated over 200 vascular nævi, thinks that "whilst electrolysis, the cautery, the high-frequency spark, and radium have their uses and are to be preferred in a small pro-

portion of cases to meet special conditions, solid CO_2 is the most useful of all, as well as the most satisfactory." In many cases solid CO_2 will answer equally as well as radium, with a great saving of time and money. There is also no risk of producing a scar with teleangiectases, such as is sometimes seen after the use of radium.

Nævus Pigmentosus

These may be divided into the small moles and large pigmented nævi.

Small brown moles, flat or raised, can be quite easily and successfully treated by CO_2 snow. The application should be from ten to thirty seconds, according to the age of the patient and the thickness of the lesion. If one freezing is not sufficient it can be repeated, but care must be taken not to overdo the applications, especially in dark-skinned individuals, otherwise the mole is replaced by an area of skin which is whiter than the rest. The scar, if visible, is as good as after electrolysis, and the effect of treatment is more easily controlled than with electrolysis, so that excessive scarring is not so likely to occur. If such moles have hairs in them, which are not destroyed by the snow, these can then be removed by electrolysis.

Large pigmented nævi are much better treated by CO_2 snow than by any known method. These nævi vary in size from that of a threepenny piece up to large disfiguring masses covering sometimes the greater part of one side of the face. Many of them, especially the larger ones, have also a very considerable growth of hair on them. I have experience of two such large nævi, both of which occupied the greater part of the left cheek in girls aged seventeen and twenty-one years respectively. Both were dark brown in colour and slightly papillomatous in the central parts. One was hairy in the central parts, with a zone of simple pigment around the edges, and the other was hairy all over. The one with the hair in the central part only has now been frozen five times, with applications of thirty seconds each time. One application was sufficient to remove entirely the non-hairy part of the lesion, but other four were necessary for the hairy parts, which were thicker. The hair has been almost entirely destroyed except for a few here and there, which it is proposed to destroy by electrolysis. There is practically no trace of scar. Except for a very slight mottling of the skin one would never know that such a disfiguring lesion had ever existed. The other case has not been under treatment long enough to effect

a cure, but each application causes a further improvement.

Pusey records a very successful result in a similar but more extensive hairy nævus covering the greater part of the side of the face of a girl. He succeeded in removing the nævus completely, leaving a whitened surface with some mottling from remnants of pigment. This mottling he has been able to remove in other cases by further applications of the CO_2 snow.

Therefore in hairy pigmented nævus, with patience and care not to overdo the applications, an almost perfect result can be guaranteed. Besides Pusey, Sutton, Zeisler, M'Leod, Hubbard, Lawrence, Morton, Zweig, Strauss, Heidingsfeld, Bunch, and Ito are all convinced of the efficiency of the CO_2 treatment in pigmented and hairy nævi.

In treating such cases, if there is much hair it should be removed by barium sulphide before making the application of the snow, so as to allow of the snow getting well in contact with the skin. The whole nævus should be gone over regularly, using a square mould, freezing either in square areas or in long strips. One application is sufficient for the non-hairy areas, and subsequent applications should be made to overlap the previous ones

so as to get the pigment removed as evenly as possible.

As in the case of vascular nævi, Pusey recommends the use of X-rays first in these large hairy pigmented nævi, not so much for the removal of the hairs as to increase the susceptibility of the tissues to the snow, so that only short applications will be necessary.

If, after freezing with CO_2 snow, only a few hairs are left, these are best removed by the electrolysis needle.

As to whether the results in these large nævi are permanent, one cannot say. Hubbard advises that a cautious prognosis in that respect should be given. In a boy of thirteen he removed a dark pigmented mole from the chin by freezing with liquid air, with an apparently perfect result; but it returned as intense as before three years afterwards. Those cases treated by CO_2 snow have none of them been under observation long enough to allow of any opinion being formed as to the permanency of the result.

Lupus Erythematosus

This disease is the one on which CO_2 snow was first tried in 1905 by Juliusberg. Good results had

previously been recorded in this disease from the use of liquid air by Campbell White, Beckett, Crocker, Trimble, and Whitehouse, therefore from solid CO_2 equally good results might be expected, and I do not think it can be said that this expectation has not been fulfilled. Morton, Sutton, Dittrich, Serrano and Nouell, Gottheil, Zeisler, Schalek, M'Leod, Grintscher, Bogrow, Lawrence, Jackson and Hubbard, Juliusberg and Zweig all wax more or less enthusiastic over its usefulness. Pusey, Gottheil, and Zeisler consider it by far the best method for treating lupus erythematosus. M'Leod obtained benefit in all his cases, but is not convinced that it is as good as zinc ionisation. Over the latter method it has the great advantage of being much less painful. The number of cases already treated must now be considerable, and the results have been uniformly good. In all there has been definite improvement, and in a great many complete cure. The form of the disease in which CO_2 does best is the chronic patchy discoid form. Before this method was introduced there was no treatment which could be relied on to produce even slight improvement. X-rays, Finsen light, and caustics of various sorts do good, but in only a percentage of cases. But even in cases which have lasted for many years

one can almost depend on obtaining a satisfactory result.

During the last eighteen months I have treated twenty-three cases of lupus erythematosus with CO_2 snow. In these the duration of the disease had been from three months up to seventeen years. In all cases the eruption was of the chronic discoid type and affected the face. In three the scalp was affected as well as the face. Seven of the cases were only seen once, so that in these the result is not known. In the others the results were uniformly good. The diseased areas were frozen for from fifteen to forty seconds, and usually for thirty seconds. Nine of the cases show complete cure of the areas treated, and as the eruption was very extensive in several of them, further treatment will be necessary to complete the cure. There is no other method which, for rapidity of result, can compete with the snow. Although in most cases the snow was applied for thirty seconds, I think almost as good results would have been obtained by applications of twenty seconds. Pusey aims at producing a stimulating reaction rather than a destructive one by the freezing, and therefore gives, as a rule, applications of from five to fifteen seconds. The disease is a superficial one, and therefore long applications are not necessary. The object

PLATE XV.

Scar after Lupus Erythematosus which was Treated with CO_2 Snow.

of the treatment is to produce sufficient inflammatory reaction with a minimum of scarring. It is better to give short applications of from fifteen to twenty seconds with not very much pressure and repeat them often rather than one long application which would leave a bad scar. After the CO_2 the scar left, if visible, is white and smooth, and very superficial, but in any case a scar would remain after the cure of the disease. I do not think the scar is any more marked than is seen in spontaneous cure or after cure by other means. The snow should always be applied a little beyond the edge of the disease, because if that is not done the disease always recurs at the edge of the patch. If there are large patches a square mould should be used and the whole area gone over systematically. Although the disease may be apparently equally frozen all over, it heals better at some places than others, and usually the healing begins in the centres of the patches first. Here and there small points of disease are left behind, and these must be frozen again. Such cases, if at all extensive, take several weeks to cure. The crust produced by the previous freezing must be allowed to fall off before one can tell how much disease is left. The photograph (Plate XV.) shows a cured case. The patient had a patch of lupus

erythematosus the size of the white area in the photograph for five years, and a cure was effected after eight visits to the hospital. The scar is white, and around the edge there is a little pigmentation, which makes it look more prominent. In only one other case have I seen this pigmented edge. A few of the cases showed a recurrence of the disease in very small points soon after apparent cure; that, I think, was due to insufficient treatment at first, so that it is a good plan to keep all cases under observation for some time, and if any small red points appear at once re-apply the snow.

If, after applications of twenty seconds or so, the disease is not yielding, longer applications up to forty seconds should be given.

The scalp cases did not do so well as the others. It is not so easy to freeze the scalp, and therefore applications of about forty seconds, with fairly firm pressure, should be used.

The occurrence of carcinoma in lupus erythematosus after CO_2 snow treatment has already been considered under the dangers of the method (p. 44).

Juliusberg has used Dreuw's method of freezing first with CO_2 and then applying crude HCl, but did not get better results than with CO_2 alone.

Tuberculosis Cutis, including Lupus Vulgaris

In lupus vulgaris the results of freezing have not, so far, been very striking. In 1900 Dethlefsen treated lupus by freezing with ethyl chloride. Whitehouse, Campbell White, and Crocker used liquid air, and report fairly good results. Juliusberg, using carbonic acid, thought that the disease was made worse. Serrano and Nouell state that CO_2 snow freezing sometimes does good, and Morton, who has treated two cases, reports encouraging results in one case. M'Leod thinks it is good in superficial lesions but not in deep ones. I have watched the results of CO_2 snow in nineteen cases of lupus vulgaris. The majority of the cases had already had treatment with X-rays, and some of them also with old tuberculin ointment. In the majority of cases the frozen areas have shown a marked improvement, but in no case can it be said that the disease has been absolutely cured. As a destructive agent in lupus the freezing has the advantage of being less painful and more quickly applied than caustics. In one case of hypertrophic lupus of the face, where the lesions stood out above the level of the rest of the skin, the frozen areas showed a very marked flattening after one freezing.

I do not think the freezing method alone should be relied on. X-rays first for a time do good, by diminishing the infiltration around the nodule, and then when isolated nodules are visible these can be frozen by the CO_2 snow. In most cases I have applied the snow with considerable pressure for thirty to forty-five seconds, and in those which had not been previously X-rayed, for sixty seconds. It is too soon yet to express any definite opinion as to the value of the method in lupus, but the results have been in most cases encouraging and quite sufficiently so to warrant its further trial.

Jackson, Hubbard, and Zweig report good results with CO_2 snow in tuberculosis cutis verrucosa. Zeisler also used it successfully in treating tuberculous ulcers.

Lymphangioma

Morton reports a cure in two cases of lymphangioma, one application of the CO_2 snow being necessary in each case. I have also obtained a complete cure after three applications, each of forty-five seconds, to a lymphangioma on the right side of the face. In this case electrolysis had been previously tried, with very little effect. In such cases the method of treatment is exactly the same as in vascular nævus.

Angiokeratoma

I have only treated one case of this rather rare disease. The patient showed the typical lesions on the dorsum of the toes. They were dark purple points, each surmounted by a horny mass. The diagnosis was confirmed microscopically. After one freezing with CO_2 snow for thirty seconds each lesion so treated disappeared.

Carcinomata, Chiefly Rodent Ulcer

Good results have been reported by Pusey, Sutton, Zeisler, Grintscher, Serrano and Nouell, Zeisler, M'Leod, Juliusberg, Schalek, Morton, and Prime in the treatment of superficial carcinomata by solid CO_2. It is difficult from the reports of these cases to tell exactly what form of carcinoma was being treated. An exact diagnosis is, unfortunately, not always given. Many of the workers only call the lesions "superficial carcinomata," and one is led to infer from what is said as to the duration of the disease and absence of gland infection that by "superficial carcinoma or epithelioma" rodent ulcer is meant.

The only definite reference I can find to the more malignant carcinomata is one by Beckett, who

claims good results with freezing in epithelioma of the lip; but owing to the very malignant nature of such lesions one would hesitate to try freezing in preference to immediate excision.

In *Rodent Ulcer*, however, we have a disease which is comparatively superficial, at least in the early stages, and one which does not tend to spread to the glands. All methods of treatment in that condition aim at a rapid and local destruction of the diseased tissue, and the comparatively painless method of freezing with CO_2 snow is found to answer the purpose very well. In treating rodent ulcers the object is to produce a total destruction of the disease, if possible, by one freezing. The duration must therefore be comparatively long, at least forty-five seconds, but sixty seconds or ninety seconds is not too long an application in larger lesions. The pressure should also be firm and graduated, according to the depth of the lesion. Sutton recommends that the lesion be frozen for from forty to forty-five seconds, and immediately after it has thawed out, again for thirty seconds or so. By that means a more intense destructive action is produced. The more superficial the lesion the better the results, but by repeated applications at intervals even fairly large lesions can be destroyed. A scar must necessarily result in the

cure of rodent ulcer, and the scar after treatment by freezing is an exceptionally good one.

I have had an opportunity of trying the CO_2 treatment in eleven cases of rodent ulcer. Two of them had been previously X-rayed. Both of these were cured, the one after one application of the snow, and the other after three applications of thirty seconds. Some of the cases have not been sufficiently long under observation to allow of a definite opinion being expressed as to whether the disease is cured or not, but in all the results have been as good as by curetting and cauterising with caustics, and more rapid than with X-rays. After one thorough freezing with CO_2 the greater part of the rodent is cured, but small foci of disease usually remain, and all such suspicious spots should be frozen again and the case kept for some time under observation in order to make sure that the cure is permanent. Zeisler recommends one freezing with CO_2 snow for sixty seconds or more, followed by the use of X-rays. This combined method is a very good one in the larger, deeper lesions. By such a combination of methods the deeper parts are destroyed by the X-rays and the more superficial by the CO_2 snow. The destruction of the surface carcinomatous tissue also allows the rays to have a deeper effect.

M'Leod, comparing CO_2 snow with radium, says that the former is good for superficial rodents, but less valuable than the latter for the deeper ones.

A safe treatment for rodent ulcer, therefore, is freezing with the CO_2 snow followed by X-rays or radium, if available.

Senile Keratoses

Excellent results in the treatment of senile keratoses have been reported by Pusey, Sutton, Jackson and Hubbard, Zeisler, Foerster, Heidingsfeld and Ihle, and Winfield.

The applications should be for from forty-five to sixty seconds with fairly firm pressure. The lesions disappear without leaving any visible mark. I have treated one such case with a perfect result. Where there is a commencing carcinomatous change the results are equally good. In such a case the freezing should be for at least sixty seconds. Pusey considers the CO_2 snow the best method we have at present for these cases. The cures obtained are permanent.

Chronic X-Ray Dermatitis with Keratoses

In this condition the CO_2 snow treatment has been very successful. Morton and Pusey report good

results by freezing the hyperkeratotic masses which arise after repeated exposure to X-rays. The snow is successful even where the lesions show commencing carcinomatous change. The CO_2 snow also gives good results in the teleangiectases which arise in X-ray dermatitis.

Juliusberg tried it in an ulcer produced by X-rays, but the result was negative.

Xeroderma Pigmentosum

In this rare disease freckle-like spots appear on the exposed parts, together with an atrophic condition of the skin and teleangiectases. After these have been present for some time multiple carcinomata develop. At present there is no satisfactory treatment. In a severe case treated in Dr. Norman Walker's ward by freezing with the CO_2 snow the results were much better than by any other method tried. The pigment could be promptly removed from any spot by one freezing. The dilated vessels also readily disappeared, and the carcinomata, which were very numerous and in some cases deep, were cured or improved by a combined treatment with CO_2 snow and X-rays.

This is the first record of the treatment of xero-

derma pigmentosum with CO_2 snow, and I would strongly recommend the method for trial in all such cases.

Verrucæ

Freezing with CO_2 snow is a convenient method for treating warts. A great many workers with the snow have obtained satisfactory results by its use. For the multiple flat warts of children short freezings of from twenty to thirty seconds are recommended by Pusey, but in the larger horny warts such as are seen on the hands of children and adults a much longer application is necessary. The snow should be firmly applied for from sixty to ninety seconds to the surface of the wart. In order to do so the stick of snow should be very firmly compressed and cut to fit the lesion. If one freezing is not sufficient it can be repeated in about three weeks. If the snow is kept strictly on the lesion no blister is produced and very little inflammatory reaction results and the wart gradually disappears. Sutton prefers, as in treating carcinomata, two consecutive applications, the first being for from thirty to sixty seconds, and after the lesion has thawed out, the second for thirty seconds. By that means he obtained good results in warts on the palms and soles. Fabry

PLATE XVI.

Wart Treated with CO_2 Snow.

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and Zweig recommend using a stick of snow of a diameter about double that of the wart. It is applied for from twenty to fifty seconds with not very hard pressure. In twenty-four hours or so a blister is formed on the top of which the wart is raised. This blister should be opened, the wart cut off from its base with curved scissors, and the area treated by dermatol zinc paste. The accompanying photograph (Plate XVI.) shows a wart treated by such a method. The dead skin of the blister has been removed, and the wart is seen projecting in the centre. If, after the blister is opened and the dead part of the wart extracted, any warty material still remains, the base of the blister should be touched with silver nitrate.

Whilst the blister is forming it is under considerable tension and is sometimes rather painful. The pain is greater in lesions on the finger-tips than elsewhere.

Morton does not time the application exactly. He trims the CO_2 snow to the size of the lesion, and with firm pressure freezes it till a narrow ring of healthy tissue around the base of the wart is white and frozen by conduction from the centre. By that means the length of the application is varied according to the thickness of the horny layer.

Pusey and Bunch recommend shaving down the wart with a razor and then applying the snow.

On the whole, I think either one long application of sixty to ninety seconds on the wart itself, or Sutton's method of two consecutive applications, is the best. The method of producing a blister is not very satisfactory and interferes much more with the usefulness of the hand than do the other methods. For warts on the palms and soles the freezing method is particularly applicable.

In soft pedunculated warts Pusey grasps the wart between the ends of two sticks of the snow, so as to freeze the wart itself without freezing the adjacent skin. The wart swells up and drops off later.

Soft filiform warts can also be removed by one application of forty-five seconds or so.

Seborrhœic warts can also be treated satisfactorily with the CO_2 snow.

Condylomata accuminata (venereal warts) have not as yet been treated with CO_2 snow, but Schein cured several cases by freezing with ethyl chloride. Therefore short applications of the snow would probably prove as efficacious. On account of the swelling caused by freezing the method would probably not be very suitable for lesions near the orifice of the urethra.

Papillomata

In addition to the contagious warts just described, simple papillomata may also be successfully treated with the CO_2 snow. Morton and Harman report a cure of such a lesion which was situated on the eyelid only 2 mm. from its margin. The lesion was frozen for forty seconds with the snow, and a fortnight later again for fifteen seconds. Healing was complete in three weeks.

Clavus

In corns upon the sole of the foot freezing with CO_2 snow has been tried. Fabry and Zweig have treated a case with several corns on the sole of the foot, which were very painful when the patient walked. Applications for sixty seconds were made to each one, and a blister produced in forty-eight hours, on the top of which was the corn. These blisters were opened with scissors. They healed in eight days, with complete cure of the corns. The patient had to stay in bed about a week. Prime also obtained good results by freezing corns. He recommends that, if the corn is on the sole of the foot, a bunion plaster with the hole over the corn should be worn so as to take the pressure off that area.

I have no personal experience of the treatment of corns by freezing, but should think that unless care were taken to have the part properly dressed, such blistered corns might readily become infected. Pressure on a corn is also extremely painful, and unless the hard central core were first softened and removed, I very much doubt if patients would submit to the pressure necessary to allow of complete freezing. If the method is used, owing to the horny nature of the lesion, an application of at least sixty seconds' duration must be given.

Callositas, Tyloma—Keratosis Palmaris et Plantaris

In the horny thickenings of the palms and soles freezing has been found to do good. Saalfeld was the first to use refrigeration in such cases. He removed a local tylosis on a finger by freezing with liquid air. The horny thickening disappeared, but recurred in six months. It rapidly disappeared again, however, after a second freezing, this time by means of a mixture of methyl and ethyl chlorides.

Fabry and Zweig treated a case of tylosis in the same manner as they treat corns, blistering the whole thickened patch by freezing it with CO_2 snow.

The whole thickened part was frozen once all over for sixty seconds. A blister formed, raising up the thickened skin, which was removed. The area healed over without any hyperkeratosis.

Zeisler also had a very good result after freezing a stubborn case of keratosis of the palms with CO_2 snow, but the result was not so good in keratosis of the soles.

As in the case of corns, when treating tylosis, the applications must be at least sixty seconds and the pressure considerable.

Chloasma

Good results in the treatment of chloasma by freezing with CO_2 snow are reported by Pusey, Sutton, Jackson and Hubbard, and Zeisler. The duration of freezing should be short—about ten seconds—and certainly never longer than twenty seconds. By such applications patches of chloasma can be completely removed without leaving any mark. It is not necessary to blister the part in order to obtain a good result. Considering the intractability of chloasma to other methods of treatment, in CO_2 snow we have a very valuable therapeutic agent in such cases.

Lentigo (Freckles)

Judging by the effect of freezing pigmented moles, one was safe to assume that freckles also could be similarly removed. Such proved to be the case. Large freckles on the forearm of a girl were frozen for different periods. Freezing for five seconds proved insufficient; an application for ten seconds removed the freckles completely; and freezing for twenty seconds produced an unnecessarily severe reaction; therefore, in such cases an application for ten seconds is the correct one.

Pusey has obtained very good results with CO_2 snow freezing in senile pigmentary patches of the face and hands. These patches of pigment in old persons are sometimes very dark, and cause a good deal of disfigurement. An application for ten seconds completely removes the colour without leaving any scar. It is not necessary to cause the formation of a blister.

Tattoo Marks and Powder Stains

Tattoo marks and powder stains have been treated with freezing by Sutton, Jackson and Hubbard, Zeisler and Heidingsfeld and Ihle. Sutton froze the marks repeatedly for forty-five seconds, but failed to remove the pigment to any appreciable extent. Heidingsfeld

and Ihle likewise found the method a failure. Jackson and Hubbard, however, removed tattoo marks and powder stains by freezing with liquid air and also with CO_2 snow. Zeisler obtained good results in a gunpowder mark in the skin, but previous to the freezing he loosened the particles by the electrolysis needle.

Meirowski has succeeded in removing tattoo marks by blistering the skin with the Finsen light, using the same method as is used in treating lupus vulgaris. The light produces a reaction with a blister very similar in appearance to that produced by freezing with CO_2 snow.

In such cases the results seem to vary with the intensity of the reaction, and probably if sufficiently long applications of CO_2 snow are used a cure of tattoo marks could be obtained, but the applications would have to be of such a duration that a scar would be produced.

Keloids and Hypertrophic Scars

Pusey is inclined to be sceptical about the permanency of the results after freezing keloids and hypertrophic scars with CO_2 snow. Jackson and Hubbard, Hoffmann, Schalek, and Serrano and Nouell all record

removal of, or improvement in, such lesions by freezing. The freezing has to be repeated before a good result is obtained. Owing to the well-known effect of X-rays on keloids and hypertrophic scars, especially on the latter, a combined method of treatment would seem to be the one from which the best results would be expected.

Molluscum Contagiosum

I have treated several molluscum contagiosum lesions by freezing with CO_2 snow. The freezing requires to be of at least forty-five seconds' duration if the lesion is to be removed.

The rounded shape of the larger lesions makes it difficult to apply the snow sufficiently accurately all over them so as to freeze the whole lesion. Short applications have no effect except in very small lesions. Even after fairly long applications the lesions are not always cured, and it seems to me that, considering the reaction which it is necessary to produce in such cases, freezing has no advantages over squeezing out the contents of the lesion and applying pure carbolic to the centre.

Adenoma Sebaceum

In this rare condition, which occurs on the faces of children who are often mentally defective, Zeisler

is the only one who has tried freezing with the CO_2 snow. Two applications produced remarkable improvement, and considering that there is no very satisfactory method for treating such cases, the CO_2 snow may prove to have distinct advantages over the older methods of electrolysis, etc.

Hydrocystoma

I have had the opportunity of treating one case of this condition with the CO_2 snow. The patient was a woman aged about sixty years, who for some months had noticed raised, clear-looking lesions scattered over the face. These were associated with excessive sweating. Some of the lesions had been present for months, others were more recent. Each lesion, which was frozen with CO_2 snow for thirty seconds, disappeared completely.

Benign Cystic Epithelioma—Trichoepithelioma

Three cases of this disease were treated by CO_2 snow with very good results. The lesions in such cases consist of small tumours, some of them solid, others cystic in character. They develop from the glands of the skin or the root sheath of the hair follicle, and microscopically consist of cystic and non-cystic growths of epithelium of a non-malignant nature,

which tend to grow so as to reproduce a structure somewhat similar to the kind of epithelium from which they have arisen. In all three cases the lesions were multiple and situated on the face. The CO_2 snow was applied for from thirty to sixty seconds to each lesion, and in most cases one application was sufficient to effect a cure. A few of the larger lesions required a second application.

Colloid Milium

A lesion which was probably of the nature of colloid milium, at the inner angle of the eye of a woman of 44, was frozen with CO_2 snow for forty seconds and completely disappeared. As the lesion was not examined microscopically, it cannot be stated definitely whether this was a colloid milium or a benign cystic epithelioma.

Xanthoma

Pusey records the excellent result which Sutton obtained by treating a case of xanthoma planum with CO_2 snow, and puts forward the suggestion that that treatment should have further trial in such cases. For lesions on the eyelids the same method may be applied as in treating vascular nævi in that

region. The applications would have to be for thirty seconds or longer, according to the thickness of tissue to be frozen.

Chronic Dermatites, including Seborrhœic Dermatitis

Some time ago Saalfeld recorded good results by freezing with liquid air in cases of "lichenoid eczema." Sutton, Zeisler, and Bunch recommend freezing with CO_2 snow in circumscribed patches of indurated "eczema." I have only had experience of its use in one such case. The patient had had a localised patch of chronic seborrhœic dermatitis about 3 inches long and 2 inches broad on the outer aspect of one leg for over twenty years. He had tried a great variety of local applications and internal medicines. I gave him several X-ray exposures, which diminished the infiltration of the skin somewhat, but the disease was still evident. One freezing with CO_2 snow for thirty seconds produced an excessive reaction with destruction of some of the skin, but with good result as to the disease. The previous X-ray treatment had made the skin more susceptible to the freezing. In treating such a case again I should not give an application of more than ten seconds' duration. The object of using CO_2 snow in such cases of chronic resistant

dermatitis is very much the same as in using strong applications, *e.g.* caustic potash, silver nitrate, etc. It aims at producing a sudden, acute, inflammatory reaction on the top of the chronic disease. In the subsequent absorption of the acute inflammatory materials the disease is also removed. In these cases, therefore, the freezing should be short, and if one application for five seconds is not sufficient it can be repeated later. Pusey recommends the method as worthy of trial in rebellious cases of chronic eczema around the anus. He also says that its use in chronic thickened patches of eczema, particularly of the palms and soles, is followed by improvement of the disease.

Dermatitis Venenata

Campbell White treated a case of dermatitis venenata by freezing with liquid air. It was a case due to the poison ivy. On one of the affected limbs he froze a circular band-shaped area round the limb by spraying it with liquid air. When the part was dressed next day this area which had been frozen was distinctly better than the rest. The disease improved much more on that part than on the unfrozen areas. So far CO_2 snow has never been used for such cases, and as the eruption is usually extensive,

it would be difficult to apply. It might, however, be useful in more chronic cases of trade dermatitis where isolated patches remain after the rest of the disease has cleared up.

Psoriasis

Juliusberg found that the results of freezing with CO_2 in psoriasis were not satisfactory, but good results were obtained by using a modification of Dreuw's method. He froze the skin first with CO_2 and then applied strong hydrochloric acid. By that means he obtained a cure. Bunch has used CO_2 snow in obstinate patches of psoriasis with satisfactory results. In my experience freezing with CO_2 snow certainly has an effect on psoriasis. I froze two circular areas in a patch of psoriasis on the elbow of a boy—one for ten seconds and the other for fifteen seconds. Both appeared as pale non-scaly areas in a few days, in contrast to the other parts of the lesion which had remained unaltered. In psoriasis a very short freezing of from five to ten seconds is to be recommended; especially on the limbs of children and females very short applications should be given. In the case of a woman, on whose leg I froze several small spots of psoriasis, one application for fifteen seconds was sufficient to produce

an ulceration of the skin. The duration of the application must of course vary with the situation. On the thicker skin of the elbows and knees a longer application can be borne. Freezing is not to be recommended as a routine treatment for psoriasis, but I feel sure that it will prove useful in chronic cases where all the disease has disappeared except a stubborn patch or two.

Lichen Planus

Saalfeld treated a case of lichen planus successfully by freezing with liquid air. A similarly good result was also obtained by freezing with a mixture of ethyl and methyl chlorides. Carbonic-acid snow has not yet been used in this condition, but one would expect to see chronic patches of lichen improve under such treatment. Of course the method would only be applicable in the chronic, localised, patchy form of the disease. The duration of the application would depend to a great extent on the scaliness of the lesion.

Erysipelas

Campbell White treated cases of erysipelas by refrigeration. He introduced liquid air into a hollow brass roller and rolled the surface of the skin with

it, producing a very transient freezing. In two cases so treated the surface temperature of the skin, the inflammation, and pain subsided at once, and in one case the patient was well in twenty-four hours. The same method could be used with CO_2 snow by "ironing" the surface with a flat piece of the snow, passing it evenly and fairly rapidly over the surface. It might also prove useful to apply it for a very short time just beyond the spreading margin, so as to produce an inflammatory reaction beyond the edge of disease and so stop its progress.

Erythema Pernio

Most of the applications which are successful in the treatment of chilblains are those which have a stimulating action. By applying CO_2 snow for not more than five seconds the lesion can be so stimulated as to lead to its absorption. In one case which I treated thus the result was good.

Erythema Elevatum Diutinum

I have treated one case of this rare condition with CO_2 snow. The patient was a female who had on the forehead, right cheek, and nose a series of raised,

bluish-red oval lesions, which were somewhat soft and œdematous to feel. At first sight they looked not unlike lupus erythematosus, but they were too "lumpy," and the surface of the skin showed no scaliness whatever. They were purely erythematous in character, and had been present for many weeks without altering in any way. They corresponded very closely to the lesions which have been described under the name of erythema elevatum diutinum.

A few X-ray exposures were given, but without result. The CO_2 snow was then applied for thirty seconds to each lesion. The smaller lesions on the forehead were completely cured by one application, but a second one was necessary for those on the cheek and nose.

Furunculosis and Carbuncle

Liquid air has been used in the above conditions by Campbell White, who says that if boils are taken soon enough they can always be aborted by freezing. Whilst the skin is frozen he pricks it with a needle to relieve the congestion. If any pus has already formed he makes a small incision. For carbuncle he considers it by far the best method of local treatment. It is less painful than any other method. One

application only is necessary to produce entire cessation of the pain. He attributes the good results to the extreme hyperæmia produced by the freezing.

I very much doubt, however, whether patients would submit to having solid CO_2 snow pressed down upon a boil. Since Campbell White's publication of these results Bier's congestion by suction cups and the vaccine treatment of these conditions have been introduced, so that I do not think that refrigeration is a method to be recommended in such cases.

Acne Vulgaris

Juliusberg obtained satisfactory results by freezing indurated lesions in cases of acne. No other worker with CO_2 snow has tried it in acne, but it is conceivable that the freezing method might lead to the rapid absorption of the large, red, lumpy lesions seen in such cases. The applications would have to be for not longer than twenty seconds, so as to avoid the risk of a scar.

Rosacea

Rosacea is a disease in which benefit might be expected from freezing. I have tried it in one case.

The disease had lasted for four years, and was treated first with a sulphur lotion and then by peeling several times with a β-naphthol, sulphur, and soft soap peeling paste. The condition got very well except for a persistent redness of the tip of the nose, on which were many large, dilated venules. Electrolysis failed to produce much improvement. After four freezings for thirty seconds each, at intervals of at least three weeks, the nose paled down, and the patient was delighted with the result. I would recommend the method for trial in all such cases of rosacea where localised areas of congested skin occur.

Granulosis Rubra Nasi

In a typical case of this condition the CO_2 snow was tried. The patient was a boy, aged fifteen, who showed a red granular condition of the skin of the tip of the nose. There was also very profuse sweating of the nose, upper lip, and eyebrows. Little beads of perspiration could be seen standing out on these situations. The red area on the tip of the nose was frozen twice all over for thirty seconds with CO_2 snow at an interval of three weeks. The redness diminished slightly, but the sweating continued the same as before.

Sycosis

Blistering the skin with liquor epispasticus has for long been a well-recognised method of treatment in sycosis, and that being so, why should not freezing with CO_2 also prove beneficial? Juliusberg is the only one who has tried it, and he states that it does good in superficial sycotic processes. The same observer also obtained good results by applying pure hydrochloric acid after freezing with CO_2 snow. The simple freezing method would certainly seem to be worth trying in addition to vaccines in such cases.

Tinea

In ringworm of the scalp the results of freezing have not been good. Campbell White tried liquid air in several cases, but it had absolutely no effect. Saalfeld used ethyl and methyl chlorides, and states that the lesions which were frozen got sooner well than those which were not. Meyer treated cases of tinea barbæ with compresses of corrosive solution, and by freezing the lesions and the skin round them twice a week with the ethyl chloride spray. He obtained a cure, as a rule, in one or two weeks.

My experience is the same as Campbell White's.

In a tinea of the scalp in a child some of the spots were frozen with CO_2 snow, but with no improvement in the condition.

Alopecia Areata

I have tried freezing with CO_2 snow in two cases of alopecia areata. One was a case where there was only one small spot of alopecia the size of sixpence. It was frozen for thirty seconds, but with no result. The other was a fairly extensive case of the ordinary type. Two circular areas in the middle of two bald patches were frozen, one for twenty seconds and the other for thirty seconds. Seven weeks later each frozen area was distinctly mapped out by a ring of hair. The hair only grew at the edges of the area frozen. The rest of the bald area, which was not frozen, showed no growth of hair at all. The freezing, therefore, in this case caused hair to grow in again. Further trial will, however, be necessary before any definite opinion can be expressed as to its value in alopecia areata.

Ulcus Cruris—Chronic Leg Ulcer

Campbell White applied liquid air by spraying it on to chronic leg ulcers, and found it of great utility.

The ulcers cleared up wonderfully, and healed rapidly. Juliusberg, by freezing with CO_2, produced a rapid cleaning of a leg ulcer followed by complete healing. Zeisler and Lawrence similarly recommend it for foul ulcers, and for stimulating healing in ulcerated legs. In such cases the applications must be short. The vitality of the surrounding tissues is not great, and the snow should only be applied for a few seconds, so to cause a hyperæmia without any actual destruction of tissue.

Syphilis—Primary

Juliusberg treated ulcerated primary sores by freezing with CO_2 and then applying strong hydrochloric acid. By that means he obtained rapid healing. I do not think, however, that freezing with CO_2 snow is likely to be much use in such cases. It would certainly cause a good deal of additional swelling around the sore.

Ulcus Molle

Soft sore has been treated by Saalfeld by freezing with liquid air. The results obtained were good. CO_2 snow has not been tried in this condition.

Local Anæsthesia

Liquid air and CO_2 snow have both been used as local anæsthetics. Campbell White says that if liquid air is sprayed on the skin, the latter immediately becomes perfectly colourless. Anæsthesia is produced and is due to a temporary paralysis of the sensory nerve terminals. It lasts not only while the anæmia exists, but for a short time afterwards. A freezing sufficient to produce anæsthesia for 10 minutes can be given without causing any more destruction of tissue than a slight desquamation of the superficial epithelium which in no way interferes with primary union. White has used liquid air thus in a great many simple operations.

He has also had very good results by applying liquid air over the spinal end of the nerve in neuralgias and herpes zoster. It is only applied once and not for sufficient time to produce blistering or ulceration. In old persons of low vitality, if ulceration does result, the patient prefers it to the pain of the neuralgia or herpes.

Malon used CO_2 snow as a local anæsthetic in thirty cases, including cases of boils, anthrax, abscesses, cellulitis, and bubo. He applies the snow for five to eight seconds. The effect is quicker, deeper, and more easily localised than with ethyl chloride, and has

a favourable influence on the inflammation, but it has the disadvantages of making the tissues very hard, and of producing only a very short anæsthesia.

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